POWER

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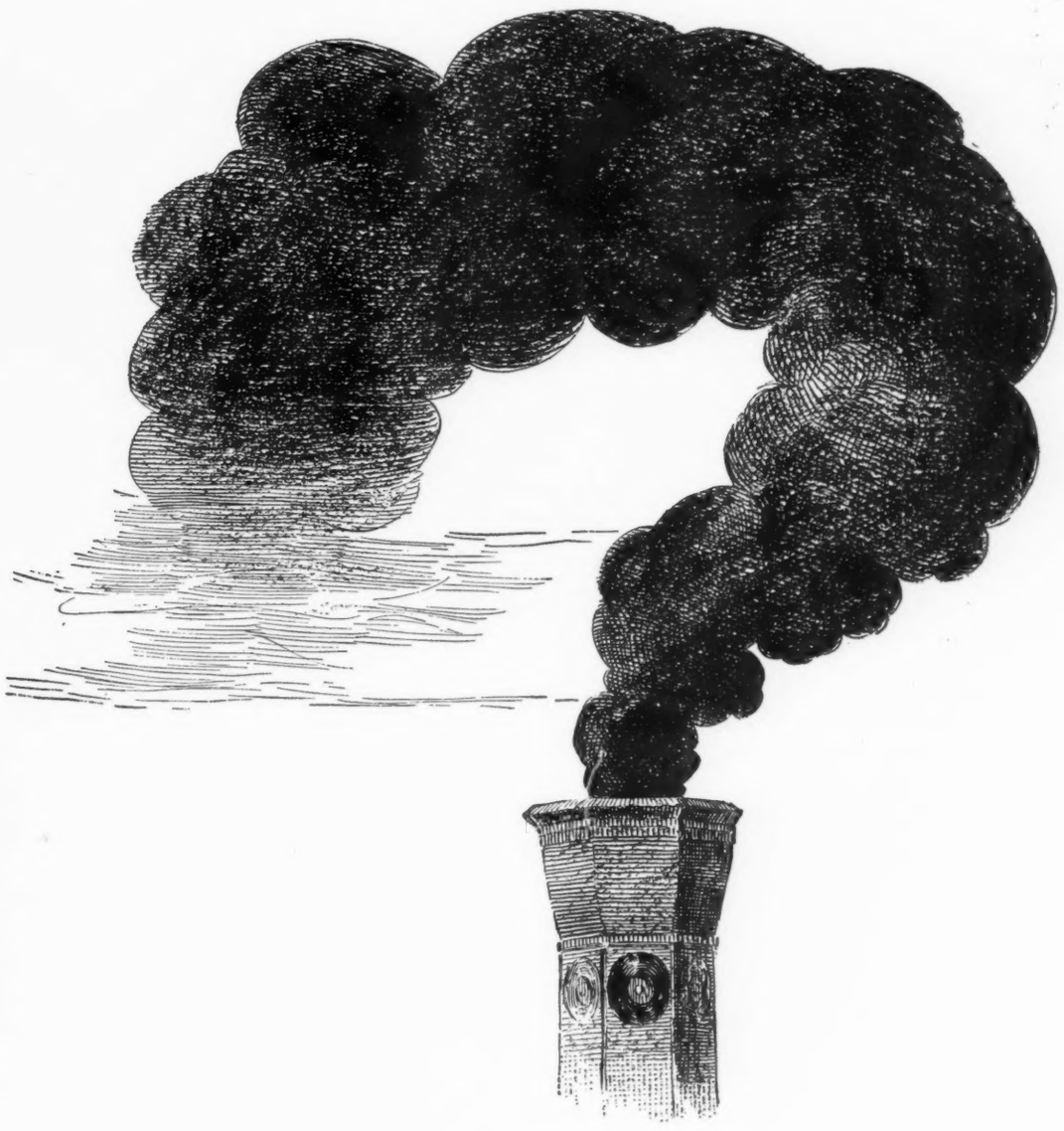


The Eternal Question

(With Apologies to C. D. Gibson)

Suggested by Charles M. Young, Philadelphia, Penn.

The Prudential Insurance Co. Plant

By Charles H. Bromley

SYNOPSIS—The power equipment for a great group of office buildings is fully described. This plant is particularly interesting for the completeness of its equipment and its remarkable growth.

Fig. 1. Boiler Room. New Section

The Prudential Insurance Co.'s plant, at Newark, N. J., which supplies power to the company's group of office buildings, is remarkable for its growth. Twenty years ago the plant's capacity was about 50 hp.; today it is 5000, of which 1500 is electrically devoted. Few office-building plants attain so rapid a growth.

In 1902, the "old plant" was completed and subsequently in 1911, the "new plant" was installed to furnish power to additional buildings, provision being made for future increased demand.

The plant occupies most of the block bounded by Broad, Academy, Bank and Halsey Sts.; the engine rooms are entirely visible from the streets. The boiler room is in two sections and is on the street level. It is spacious, admirably ventilated and lighted, as the skylights are large, and the walls are finished in white-enameled brick.

There are 12 water-tube boilers, eight of which are of 250 hp. each and are in the old section, while the remaining four are of 550 hp. each, and are in the new section. Those in the old section are of the two-drum type, while those in the new section are of the three-drum type. They are supplied with forced-draft from two engine-driven fan blowers of 10-ft. diameter in the cellar under the boilers with the air intake on top of the boilers to obtain the heated air and force it under the grates.

No. 1 buckwheat coal is burned, and supplied by gravity to semi-circular boxes in front of the boilers through extra heavy chutes from bins of 600 tons capacity each, above the boiler room. The chutes in the new section extend vertically to avoid the excessive wear experienced with the inclined ones in the old section. The coal first passes through automatic weighing and registering machines under the sidewalk at the head of each belt conveyor, which carries it into the cellar where it is dumped into bucket conveyors that raise it to the overhead bins. The ashes are dropped from hoppers under the grates directly into these conveyors and carried by them to trippers, which dump them into chutes leading to ash chambers over each driveway in each boiler room from which they may be loaded directly into wagons. A view of the new boiler room, showing the vertical coal chutes, may be seen in Fig. 1.

After the new boilers were installed and carrying the entire load, the grate area of the old ones was enlarged

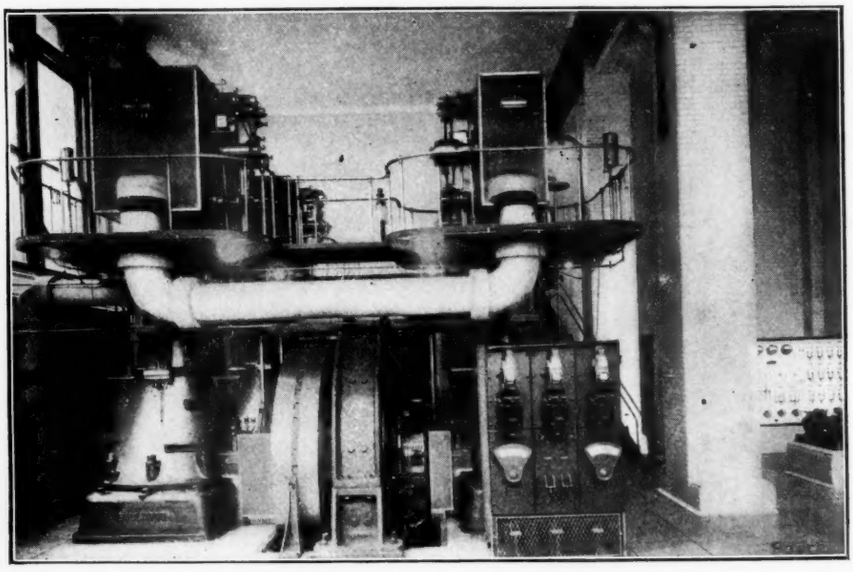


Fig. 2. New 750-hp. Units and Contactor Panel

by placing the bridgewall back 2 ft., thus giving the grates a depth of 9 instead of 7 ft. The average daily coal consumption is 50 tons. The CO_2 production averages 15 per cent. This serves to indicate the thoroughness of the boiler-room equipment and the excellency of firing. Damper regulators, draft gages and a recording pyrometer are also provided.

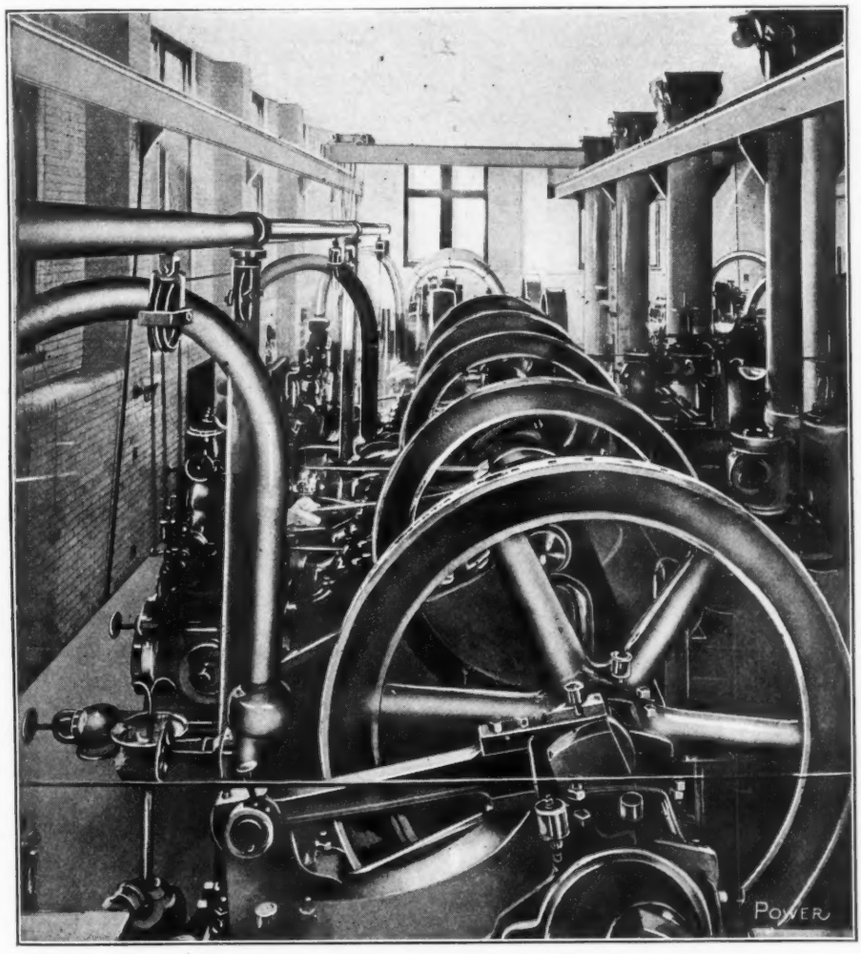


FIG. 4. OLD ENGINE ROOM, ELEVATOR PUMPS IN FOREGROUND; GENERATING UNITS IN REAR

Steam at 150 lb. is led to headers, the piping of which is so arranged that any number of boilers in either section may be cut in or out of service without interruption of the steam supply. Non-return stop valves are in all lines from the boilers to the headers. A separate steam line is run to one of the 250-hp. engines so that ordinary steam main troubles will cause no interruption of the electric service. The same is true of lines to the feed pumps and injectors. Uninterrupted service is the chief consideration in this plant. City water is filtered and heated by exhaust steam to 212 deg. F., before going into the boilers, as shown by a recording thermometer, the temperature being automatically controlled by a compressed-air-operated thermostat controlling the admission of steam to the heater. The feed pumps, located in the cellar, are of the duplex vertical type.

ENGINES AND GENERATORS

There are two engine rooms, one floor below the street level, but with ceilings rising to the floor above this level. The old engine room fronts on Bank and Halsey Sts., and the new one on Academy and Halsey. They are separated by the boiler room and refrigeration plant through which leads a passageway connecting them on the same level. This passageway greatly facilitates communication to and from each engine room.

Previous to the new three-wire system installation, 120-volt generators were used on a two-wire system. These were displaced by 240-volt generators, which are used throughout; all are directly connected to their engines.

The change-over from the 120-volt, two-wire system to the 240-volt, three-wire system was made without an interruption of service. It must be remembered that the wiring throughout all the buildings had to be likewise changed and this was also done without interrupting the service. All of this required installing temporary switchboards, panel boxes, circuits, etc.

In the old engine room are three 250-hp. and one 175-hp. horizontal tandem-compound four-valve non-condensing engines each directly connected to 240- and 150-kw. generators respectively.

The two units in the new engine room are of the vertical cross-compound type, and of 750 hp. each, di-

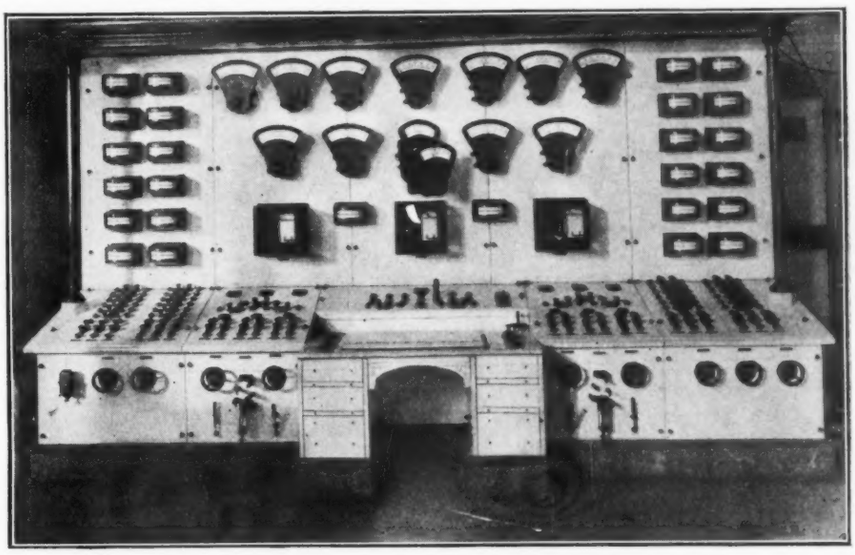


FIG. 3. MAIN SWITCHBOARD, REMOTE-CONTROL TYPE

rectly connected to 500-kw. generators. The foundation for another of these large units is provided alongside the present ones. All units are noncondensing. The new engine room and the new units are shown in Fig. 2.

Switchboard

The switchboard (Fig. 3) is of the remote-control type, reflector, which throws light over the entire board. Space would not admit of placing the contactor board in the engine room, so it was located in a small room in the cellar, as nearly central to the generators and point of distribution to the sub-switchboards as possible. Connection of the generator leads could not be made in the generator pits, so contractor panels, each having a volt-

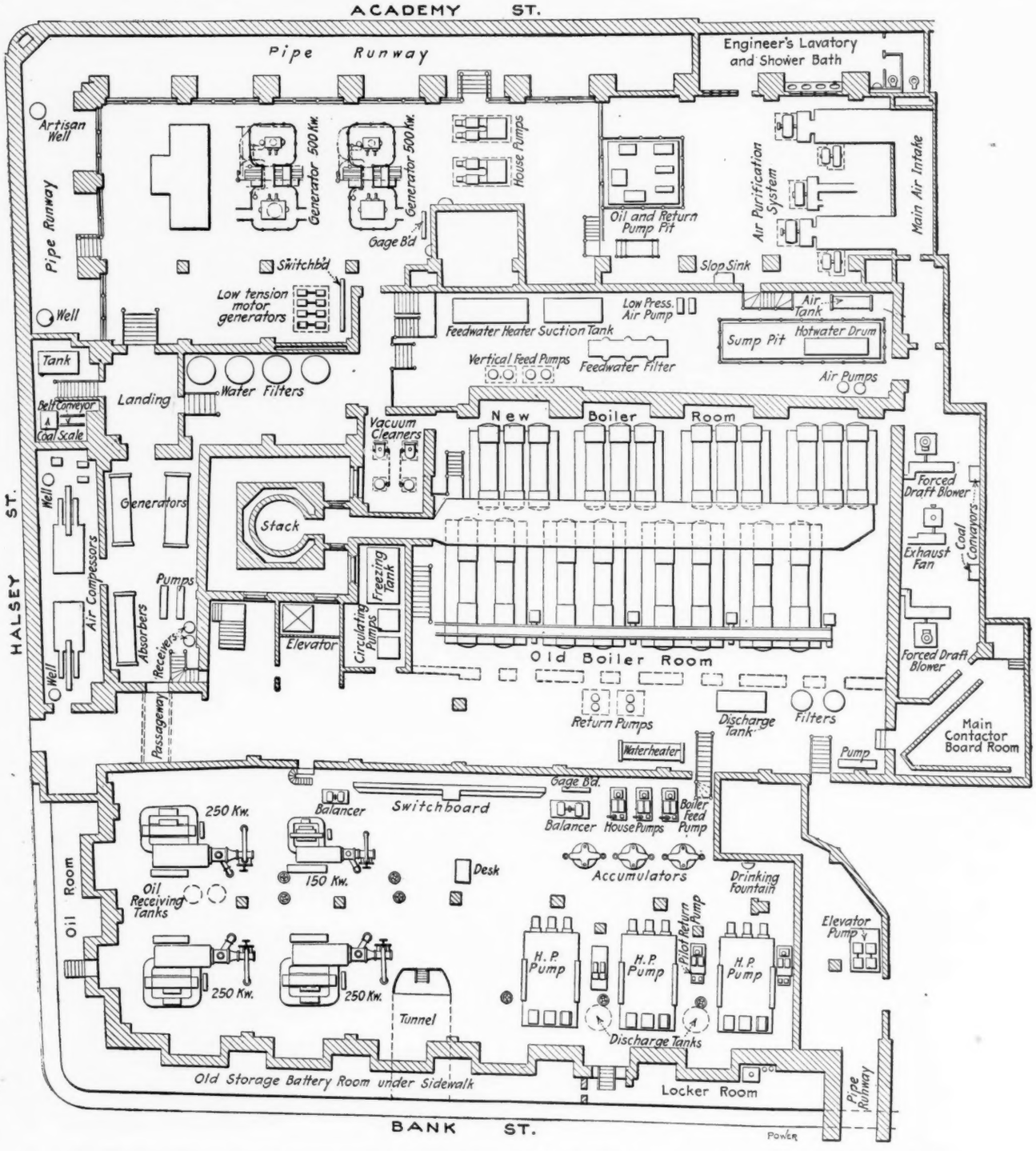


Fig. 5. Diagram of Prudential Insurance Co.'s Plant, Showing Location of Equipment

located in the old engine room, and is considered the finest of its kind in the world. An impressive decorative feature of the board is the two art bronze columns at each end supporting the head work and the mottled glass meter, ammeter, positive, negative and equalizer solenoid-operated switches controlled by pull switches on the main control board were installed. These pull switches have both electric and mechanical signals to show whether the

circuits are open or closed. Two balancer sets capable of caring for an unbalance of 800 amp. establish the neutral leg. The busbars of the generator panels connect to large main busbars that are run under the old boiler room and there connect with the busbar leads from the generators in the old engine room.

Telephones and a push-button signal system permit code signaling from and to both engine rooms. A gong on the control board operated through a relay on the generator contactor panels continues to ring when a circuits opens until stopped by the operator. The affected circuit is also indicated by signal lamps. As it is most important that the plant and cellars be not in darkness, plug-switch receptacles connected to lines from the generator panels are provided. If a generator circuit is opened, the plugs may be inserted in any pair of terminals, thus connecting the lamp circuits back of all circuit-breakers.

Motor-generator sets furnish current at 24 volts for all annunciator, clock and signal service, no battery being used. The sets and low-tension switchboard are shown at the right in Fig. 2. The low-tension system complete is said to be the most elaborate ever installed. This is due to the size and number of buildings.

and three hoists which operate under 750 lb. with a suction pressure of 75 lb. There are seven electric elevators in the Broad St. end of the north building, four of which are of the high-speed traction type and three of the drum type. There are also eight electric dumb waiters.

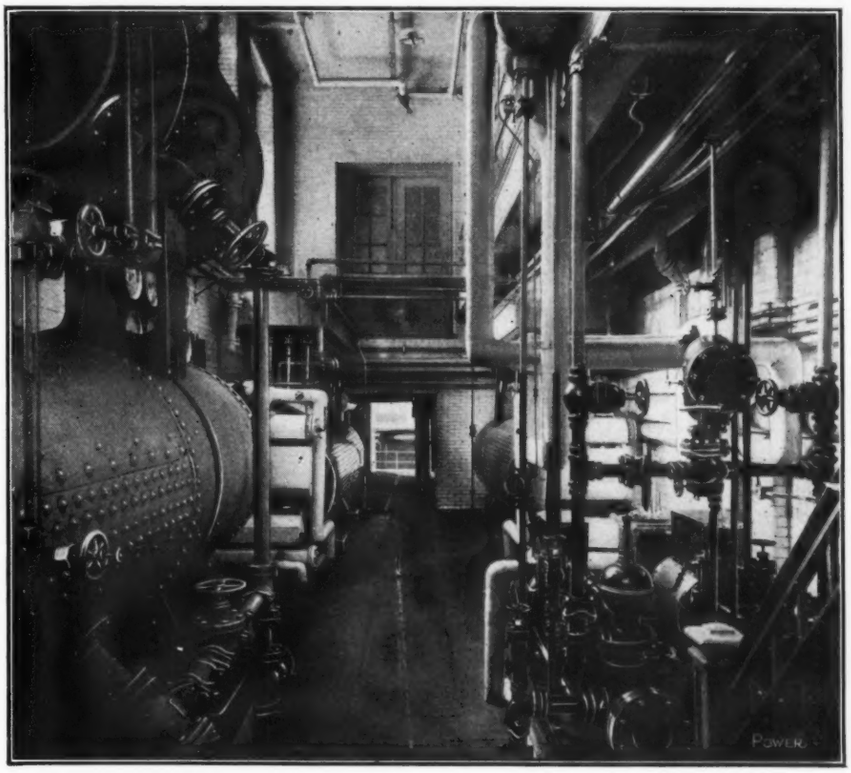


FIG. 6. REFRIGERATION PLANT. ABSORBERS IN FOREGROUND

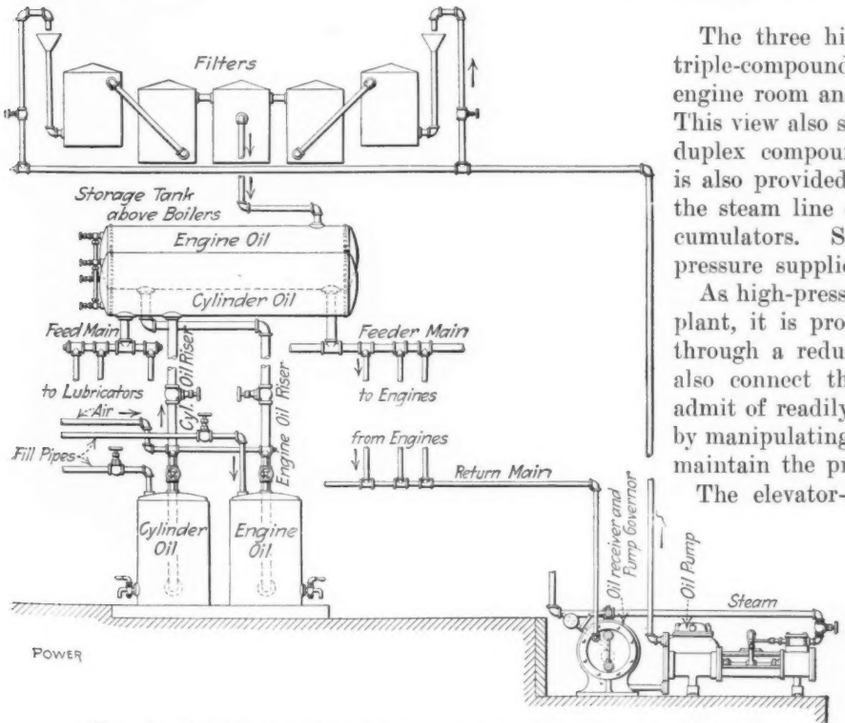


FIG. 7. COMPLETE OIL SYSTEM IN THE PRUDENTIAL PLANT

ELEVATOR EQUIPMENT

There are 36 high-speed, high-geared, plunger passenger elevators, two of the direct-acting plunger type

The three high-pressure elevator pumps are of the triple-compound flywheel type. These are in the old engine room and are shown in the foreground of Fig. 4. This view also shows the old generating units. A smaller duplex compound pump for night and Sunday service is also provided. All pumps are controlled by valves in the steam line operated by cables actuated from the accumulators. Special safe-lifts operate under 2500 lb. pressure supplied by a special pump.

As high-pressure (150-lb.) water service obtains in the plant, it is proposed to connect a high-pressure line through a reducing valve to the pilot-water system and also connect this system with the sewer. This would admit of readily cleaning this part of the elevator system by manipulating a few valves, as the reducing valve would maintain the pressure while the pumps were idle.

The elevator-shaft doors are each electrically locked by a device controlled through contacts made by the movement of the car. This prevents accident, as no door can be opened until the car is at that door. All cars have meters that register the travel in miles. This admits of accurately determining by reference to record the wearing qualities of the cables, etc.

A diagram of the entire plant showing the location of the machinery, artesian wells, tunnel, lavatories, etc., is given in Fig. 5.

Refrigeration Plant

Two 35-ton absorption plants connected in multiple, cool all drinking water used throughout the buildings to 40 deg. F. The generators are operated entirely by exhaust steam. Motor-driven centrifugal pumps furnish condensing water and motor-driven triplex pumps circulate the cooled water through the various lines. The generators, absorbers, condensers and ammonia circulating pumps are shown in Fig. 6.

Two engine-driven air compressors are in the refrigeration plant, furnishing air at 75 lb. for lifting water from four driven wells, which supply 300,000 gal. daily. City water was formerly used for house purposes, but well water is now used, which has effected a saving of many thousand dollars in the cost of water. Due to its constant low temperature this water is excellent for use in the condensers of the refrigeration plant. The cost of operating the refrigeration plant is chiefly that incurred by pumping, as the exhaust for operating it is most plentiful when the demand on the plant is greatest, i.e., in the summer. The condenser-water circulating pumps are of the motor-driven volute type, while the drinking-water circulating pumps are of the motor-driven triplex bronze-plunger type. The house-water pressure is 80 lb., which is that due to the head of water from a tank in the North building tower. The tower is beautifully decorated with lamps and at night is the most imposing feature of Newark's illumination.

Oil Storage and Distribution System

On account of the scattered location of the various engines, pumps, etc., the distribution of oil to them was

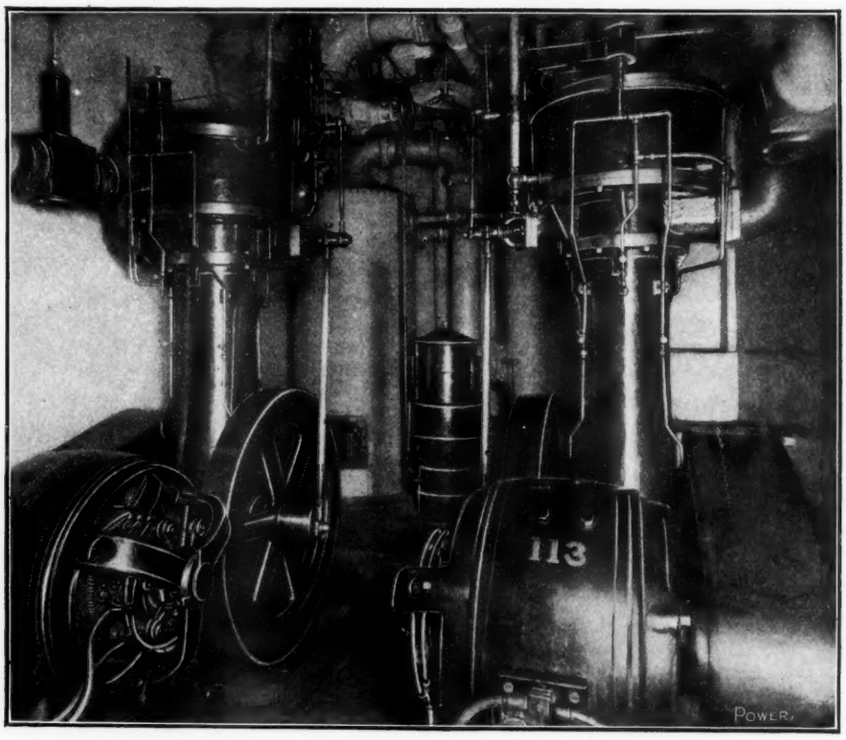
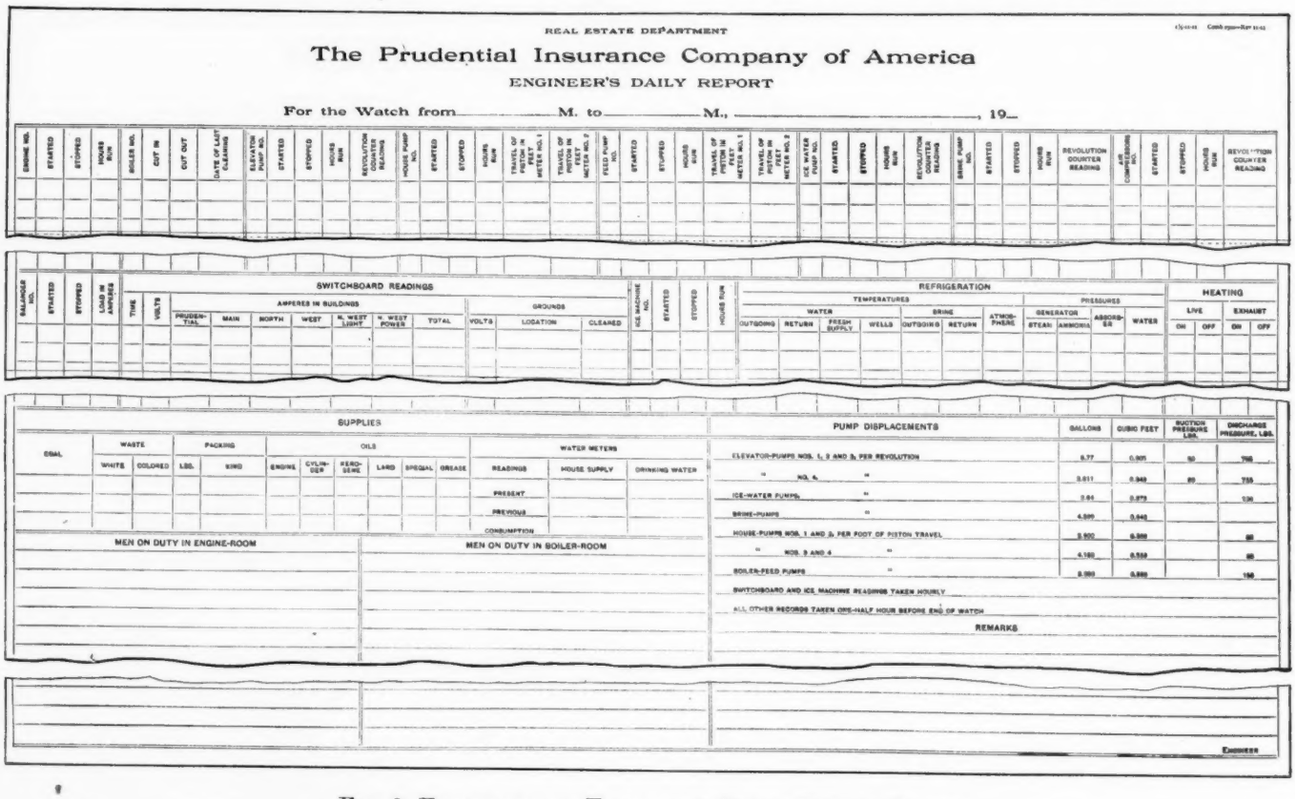


Fig. 8. Vacuum Cleaners in New North Building


REAL ESTATE DEPARTMENT

The Prudential Insurance Company of America

ENGINEER'S DAILY REPORT

For the Watch from ____ M. to ____ M., ____, 19__

SWITCHBOARD READINGS — AMPERES IN BUILDINGS: PRUDENTIAL, MAIN, NORTH, WEST, N. WEST LIGHT, N. WEST POWER, TOTAL; GROUNDS: VOLTS, LOCATION, CLEANED; TIME, VOLTS, BALANCER NO., STARTED, STOPPED, LOAD IN AMPERES; ICE MACHINE NO., STARTED, STOPPED, HOURS RUN

REFRIGERATION — TEMPERATURES: WATER (OUTGOING, RETURN, FRESH SUPPLY, WELLS), BRINE (OUTGOING, RETURN), ATMOSPHERE; PRESSURES: GENERATOR (STEAM, AMMONIA), ABSORBER, WATER

HEATING — LIVE (ON, OFF), EXHAUST (ON, OFF)

SUPPLIES — COAL; WASTE (WHITE, COLORED); PACKING (LBS., KIND); OILS (ENGINE, CYLINDER, KEROSENE, LARD, SPECIAL, GREASE); WATER METERS (READINGS: PRESENT, PREVIOUS, CONSUMPTION; HOUSE SUPPLY; DRINKING WATER)

PUMP DISPLACEMENTS — GALLONS; CUBIC FEET; SUCTION PRESSURE LBS.; DISCHARGE PRESSURE, LBS.

ELEVATOR-PUMPS NOS. 1, 2 AND 3, PER REVOLUTION — 0.77 — 0.001 — 80 — 700

" NO. 4, " — 0.611 — 0.040 — 80 — 700

ICE-WATER PUMPS, " — 0.61 — 0.079 — — 120

BRINE-PUMPS " — 4.590 — 0.640 — — —

HOUSE-PUMPS NOS. 1 AND 3, PER FOOT OF PISTON TRAVEL — 3.900 — 0.500 — — 80

" NOS. 2 AND 4 " — 4.160 — 0.550 — — 80

BOILER-FEED PUMPS " — 0.980 — 0.980 — — 150

SWITCHBOARD AND ICE MACHINE READINGS TAKEN HOURLY

ALL OTHER RECORDS TAKEN ONE-HALF HOUR BEFORE END OF WATCH

MEN ON DUTY IN ENGINE-ROOM

MEN ON DUTY IN BOILER-ROOM

REMARKS

Engineer

Fig. 9. Fac-simile of Engineer's Daily Report Sheet

a problem best overcome by the oil-storage and distribution system, designed especially for the plant by its chief and assistant chief engineers, who also designed the oil filters, which will handle two barrels an hour. The filters, shown at the top of Fig. 7, have run over a year without cleaning and the oil leaving them now is perfectly clean. There are two sets of filters so piped as to allow of quickly changing over if one should overflow. This, however, has never happened, owing chiefly to the ample head at the filter inlet.

The oil is handled as follows:

In barrels it is dropped from the street to the "oil room" by a sidewalk lift. From the barrels it gravitates through fill pipes to receiving tanks in the cellar, as shown in Fig. 7. When the barrel is empty the valve in the fill pipe is closed, compressed air at 40-lb. pressure is then admitted to the tank, the valve in the riser to the storage tanks over the boilers is then opened and the oil forced to them. The compressed air is taken from the receiver supplying the deep-well water air-lift system. The receiver pressure is 75 lb., but is stepped down to 40 lb. by a reducing valve before being used in the oil tanks. When the oil-receiver tank is emptied the valve in the riser is closed and the air pressure cut off. The oil then gravitates through the feeder mains to the engines. Thence it runs to a receiver and small duplex pump in a pit and continues to the filters over the storage tanks, the oil runing by gravity to the storage tanks from the filters. The cylinder oil gravitates to all lubricators and oil fountains throughout the plant. The system works admirably, the only trouble encountered being the plugging of the valves of the "dirty oil" pump with waste which gradually accumulates. This is obviated by cleaning the pump chambers frequently. All machines (except a few pumps) requiring internal lubrication have force-feed lubricators.

Drips and Drains

The drainage or sanitary sewage is mostly below the sewer, so it is run into a receiver in a sump below the lowest drain level. From the receiver it flows to an ejector, which discharges it to the sewer. The ejector has a float, raised and lowered by the level of the liquid within it, which operates a valve in a compressed-air line when the ejector is full and allows the air to enter and force the liquid to the sewer. The ejector-inlet pipe has a check valve to prevent the liquid from running out when discharge occurs. A check valve in the discharge pipe prevents any inflow from the sewer. The above applies to the "new plant" only. In the "old plant" the drainage collects in pits from which it is pumped to the sewer automatically.

The drips from the steam headers, mains and all piping in the "new plant" are trapped and collected in a receiver below the traps. They are then carried to a discharge chamber at the top of the boiler house and from there are discharged into the boilers. The drips in the old plant are trapped and discharged into the feed-water heater.

Vacuum Cleaners

The vacuum-cleaning plant is divided into two sections, one in the basement of the Main building, the other in the basement of the new North building. At present the one in the Main building takes care of the Main, Prudential and West buildings, while the other two machines furnish vacuum for the North and New North buildings. Only those in the North building are shown in Fig. 5.

The machines are motor-driven, as shown in Fig. 8, which illustrates the North building machines. The vacuum lines are piped throughout the entire buildings, including the boiler and engine rooms. The tops of the boilers and headers are cleaned by vacuum.

Machine Shop

There is a complete machine shop for doing repair work and making new parts for worn machines. This shop is a necessity as outside of the many repairs to, and new parts to be made for the equipment, there is much work to be done and renewals needed by the kitchens and printing establishment. The latter occupies nearly all of the West building. The four lower floors are crowded with printing machinery, the minor repars to which are in charge of the chief engineer.

The shop equipment consists of three quick-change lathes, one 26-in. swing, 18-ft. centers, and two 16-in. swing and 14-ft. centers; four vertical and one radial drill presses, two shapers, two emery wheels, two power hacksaws and two grindstones. All except the grindstones are driven by direct-connected individual motors.

Records and Data

Fig. 9 shows the engineers' daily report sheet. One of these is made out for each of the three watches. The report sheet is very complete and yet is not burdened with useless items. There is also a weekly report sheet, filled out by the foreman of the elevator repairmen. This report includes the headings: *Location,* under which is recorded location, number, and kind of each car, *Dumbwaiter* and *Hoist, Cylinders and Plunger, Sheaves, Operating Valves, Car and Safeties, Cables, Counter Readings* and *Supplies Used and Wanted.* At the bottom of the sheet space is left for reporting the condition of, and the repairs to, each of the nine accumulators.

A card system is kept on which is recorded all data relative to each of the great many motors throughout the buildings, the kind of service performed, size, number; size, number and kind of brushes, kinds of repairs and renewals and dates made are all recorded on these cards, one of which is made out for each motor. The purpose of these cards is to facilitate the ordering of parts.

Besides the various filled-in report sheets are the charts from the recording instruments, which are provided wherever needed. The records, therefore, are exceedingly complete.

Labor and Watches

Including the electrical division of the engineering department, there are forty employees under the direct supervision of the chief and assistant chief engineers and a chief electrician. Each of the three watch engineers has an assistant engineer on watch with him. Each man has a particular part of the equipment assigned to him. The direction of the detail work for the whole plant, exclusive of the electric lighting, is in charge of the assistant chief engineer.

The watch engineers, their assistants, oilers, switchboard tenders and firemen work in 8-hr. watches, shift-

ing about every two weeks. The switchboard-tenders are in charge of the dynamo-tender, who is responsible for all motors and generators. The other men, including steam fitters, plumbers, pumpmen, cleaners, etc., work 9-hr. all-day watches, each man taking his turn at Sunday work.

PRINCIPAL EQUIPMENT OF THE PRUDENTIAL INSURANCE COMPANY'S PLANT

No.	Equipment	Type	Use	Kw.	Volts	Amp.	R.p.m.	Size	Pres.	Hp.	Manufacturers.
8	Boilers	Water-Tube	Steam Generation	....	...	....	.....	.....	160	250	Babcock & Wilcox Co.
4	Boilers	Water-Tube	Steam Generation	....	...	....	.....	.....	160	500	Babcock & Wilcox Co.
3	Engines	Tandem-Compound	Main Unit	....	...	....	.....	17x30x18 in.	160	325	Ball & Wood EngineCo.
2	Engines	Vertical Cross-Compound	Main Unit	....	...	....	.....	21x35x30 in.	160	750	Ball & Wood Engine Co.
1	Engine	Tandem-Compound	Main Unit	....	...	....	.....	12x22x16 in.	160	175	Ball & Wood Engine Co.
3	Generators	Direct Current	Main Unit	250	240	1000	175	.....	...	...	Sprague Elecgric Co.
2	Generators	Direct Current	Main Unit	500	240	2000	150	.....	...	...	Sprague Electric Co.
1	Generator	Direct Current	Main Unit	150	240	600	225	.....	...	...	Sprague Electric Co.
1	Balancer	Direct Current	Load Balance	50	125	400	925	.....	...	...	Sprague Electric Co.
1	Balancer	Direct Current	Load Balance	30	125	240	925	.....	...	...	Sprague Electric Co.
1	Switchboard	Remote Control	Electrical Control	....	...	....	.....	.....	...	...	General Electric Co.
1	Switchboard	Remote Controlled	Main Contactor Board	....	...	....	.....	.....	...	...	General Electric Co.
4	Motor-Generators	Direct Current	Low Tension Electric System	....	20	30	1200	.....	...	...	Holtzer-Cabot Co.
3	Flywheel Pumping Engines	Triplex-Compound Corliss	High-Pres. Elevator System	....	...	....	.....	15x18x18x4¼x24 in	750	...	Laidlow-Dunn-Gordon Co.
1	Pump	Duplex Compound	High-Pres. Elevator System	....	...	....	.....	12x18¼x4x12 in.	750	...	Laidlow-Dunn-Gordon Co.
2	Pumps	Duplex Compound	Pilot Pres. Elevator System	....	...	....	.....	5¼x7¼x6x10 in.	80	...	Laidlow-Dunn-Gordon Co.
1	Pump	Duplex	Safe-Lift	....	...	....	.....	9x2¼x10 in.	2500	...	Laidlow-Dunn-Gordon Co.
2	Air Compressors	Single-Stage	Compressed Air Supply	....	...	....	Variable	12x20x12 in.	75	...	Ingersoll-Rand Co.
2	Pumps	Direct Acting	Ammonia Circulation	....	...	....	.....	.....	...	...	Foster
2	Pumps	Double-Acting Triplex	Brine Circulation	....	...	....	.....	5½x8 in.	...	...	DeanBros. Steam Pump Works.
2	Pumps	Single-Acting Triplex	Icewater Circulation	....	...	....	.....	5x8 in.	...	...	Dean Bros. Steam Pump Works.
2	Pumps	Duplex	Ammonia-Return	....	...	....	.....	6x6 in.	...	...	H.R.Worthington Co.
2	Generators	Steam Heated	Refrigeration Plant	....	...	....	.....	35 tons	...	...	Carbondale Machine Co.
2	Absorbers	.....	Refrigeration Plant	....	...	....	.....	35 tons	...	...	Carbondale Machine Co.
2	Condensers	.....	Refrigeration Plant	....	...	....	.....	.....	...	...	Carbondale Machine Co.
1	Heater	Open	Feedwater Heater	....	...	....	.....	.....	...	...	Standard Steam Specialty Co.
2	Pumps	Vertical-Duplex Compound	Boiler Feed	....	...	....	.....	12x17x15 in.	...	...	H. R. Worthington Co.
2	Pumps	Duplex-Compound	House Water Supply	....	...	....	.....	9x4x15 in.	80	...	H. R. Worthington Co.
2	Pumps	Duplex	House Water Supply	....	...	....	.....	10x10 in.	80	...	Laidlow-Dunn-Gordon Co.
4	Pumps	Duplex	Oiling System	....	...	....	.....	3x3 in.	...	...	H. R. Worthington Co.
6	Filters	.....	City Water Filtration	....	...	....	.....	.....	...	...	Continental Jewel Filteration Co.
2	Filters	.....	Icewater Filtration	....	...	....	.....	.....	...	...	Continental Jewel Filteration Co.
1	Condensate Return System	Gravity Holly Loop	Drip Return to Boilers	....	...	....	.....	.....	...	...	Westinghouse-Church Kerr Co.
5	Ejectors	Compressed Air	Waste Water Lift to Sewer	....	...	....	.....	.....	...	...	Shone Co.
2	Engines	Slide-Valve	Forced Draft Fans	....	...	....	.....	.....	...	...	B. F. Sturdevant Co.
2	Coal Conveyors	Bucket	Coal Transportation	....	...	....	.....	.....	...	...	Old—McCorbin Co. New—Campbell Co.
2	Coal Conveyors	Belt	Coal Transportation	....	...	....	.....	.....	...	...	Old—McCorbin Co. New—Campbell Co.
2	Coal Weighers	Balance	Weighing Coal	....	...	....	.....	.....	...	...	Richardson Auto. Scale Co.
2	Vacuum Cleaners	Pump-12 Sweepers	Vacuum Cleaning	....	...	....	.....	.....	...	...	Vacuum Cleaner Co.
1	Vacuum Cleaner	Pump-25 Sweepers	Vacuum Cleaning	....	...	....	.....	.....	...	...	Kenney Co.

As shown in the diagram, Fig. 5, the men are well provided with locker rooms, lavatories and tub and shower baths. The heating equipment of this plant will be described in a later issue.

The writer desires to thank E. G. Lender, chief engineer, W. H. Sergeant, assistant chief engineer, and the George B. Post Co., architects of the Prudential buildings, for their assistance in the preparation of this article.

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Why a Recently Blown Column Shows a Higher Water Level

It is a matter of common observation that if a water column or gage glass which has been standing so long that the water in it has become cool, is blown off, the water level indicated will be higher. The reason for this is that the colder water with which the column is filled after standing weighs more per cubic inch, and a shorter column of it will balance a longer column of hotter water.

If water be poured into a U-tube, as in Fig. 1, until it stands at the level *a* in the left-hand leg, it would also stand at the level *b* in the right-hand leg if it were of the same temperature. Suppose now the water in the right-hand leg to be heated up, this heating does not change the weight of the water in that leg, but simply its volume, and it pushes upward to *c* without pushing the level at *a* up at all, because in its heated condition the column *ec* weighs no more per unit of section than the cooler column *ad*.

In Fig. 2 it is shown that this condition does not require equality in the size of the leg, and in Fig. 3 that one of the legs of the tube may be the water column and its connections, and the other leg the boiler to which they are applied.

At 80 deg. Fahrenheit one cubic foot of water weighs

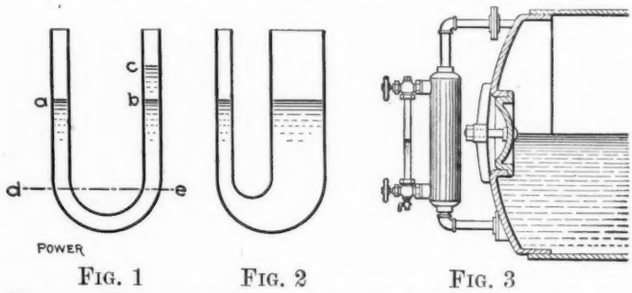


FIG. 1 FIG. 2 FIG. 3

WHY A RECENTLY BLOWN COLUMN SHOWS A HIGHER WATER LEVEL

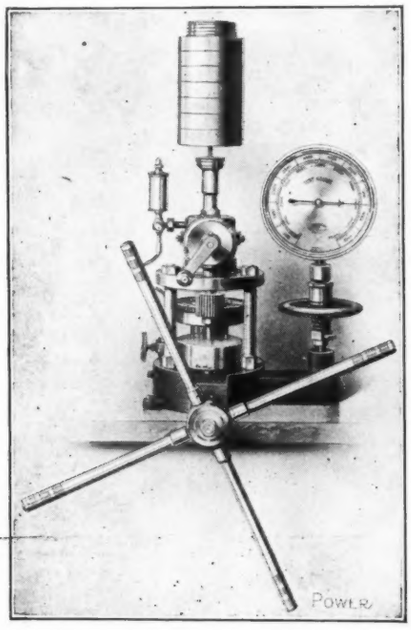
62.22 lb., at 340 deg., corresponding with the pressure of 118 lb. absolute, 55.94 lb., or only about nine-tenths as much as at the lower temperature. The cooler column would therefore have to be only about nine-tenths as high as the lighter column, or for a column 30 in. in length there might be, under these conditions of temperature, a difference of three inches.

American Multipar Hydraulic Dead Weight Tester

This is an accurate hydraulic dead-weight gage tester in which each 10-oz. weight will calibrate from 1 to 100 lb. per sq.in. pressure, and a 6¼-lb. weight from 100 to 1000 lb. pressure. Multiples of these dead weights make the tester's usefulness practically unlimited, it being as simple to calibrate a 25,000-lb. gage as one of 5 lb.

This range is secured through a simple system of multiple pistons, two of which are fixed and permanent. The top cylinder has two interchangeable pistons, the larger being used for pressures from 1 to 100 lb. per sq.in.: the smaller for from 10 lb. to whatever pressure is desired. The outfit as regularly supplied will test up to 25,000 lb. per sq.in.

The tester consists of three cylinders, three pistons and two pressure chambers—upper and lower. The top piston and cylinder give 1-lb. pressure for every ounce applied, so that a 10-oz. weight will give 10-lb. pressure in the upper chamber. This pressure is exerted on a piston 1 sq.in. in area, which is fitted into the lower part of the upper chamber. This larger piston is in direct line and in communication with a smaller piston fitted into the lower cylinder and pressure chamber. The piston in the lower cylinder has a known area which multiplies whatever force is exerted on the end of the larger piston, and the pressure thus created is communicated directly to the gage being tested.



High-pressure Gage Tester

Low pressure tests are made by opening a bypass connecting the upper and lower cylinders, which allows the pressure, created by a pressure screw in the lower chamber, to be transmitted directly to both the upper chamber and the gage being tested. The instrument is thus converted into the original direct dead-weight tester, and can be used on pressures from 100 to 1 lb. per sq.in.: pressures of less than 10 lb. can be obtained by substituting a piston supplied with the outfit for the upper cylinder which will give 1 lb. pressure for each 10-oz. weight.

The tester is made by the American Steam Gauge & Valve Manufacturing Co., Boston, Mass.

❖

Value of Boiler Specifications

By F. W. Rose

Nearly every issue of certain technical papers contains one or more accounts of boiler failures or explosions, which have been more or less destructive to life or property; many more accidents happen accounts of which never reach the technical press.

Some of these accidents could be eliminated if all boiler manufacturers were required to follow more closely high-grade specifications in the building of their boilers.

Generally the purchaser depends on the manufacturer or his agent to tell him how the boiler should be built, or, more often, the purchaser tells the manufacturer that he wants a boiler of a certain size for a certain pressure, and nothing is said about the quality of material or workmanship.

All reliable boiler insurance companies have certain standards to which boilers must conform if approved by the company.

If the purchase of the boiler is left to a responsible consulting engineer, it is his duty to see that the boiler is built according to high-grade specifications.

The following aptly illustrates the advantages of buying according to specifications.

Specifications were issued for the purchase of a horizontal return tubular boiler, and the contract was let to a supposedly reliable manufacturer of high-grade boilers. The boiler was delivered ready for erection, before an inspection was made by the consulting engineer, who rejected the boiler on the grounds that it did not conform to the specifications under which it was purchased. An inspection was then made by the inspector of a reliable insurance company. This inspector reported that 18 new tubes must be put in before the insurance company would accept the boiler. The boiler was not accepted, and another boiler was furnished by the same company, but it did not conform to the specifications, and was likewise rejected; a third boiler, which did conform to the specifications, was furnished by another company.

There was nothing special about the specifications, and any first-class boiler shop could have lived up to them if they had so desired.

The principal objections to the first two boilers were that the tubes were too short to allow for proper beading, and were weakened from excessive rolling; the first boiler was several inches shorter than called for.

In all probability either one of the rejected boilers would have been installed, had there been no specifications to which the manufacturer had to conform, and would perhaps have performed the service required. Nevertheless, there was a weakness which might have resulted in a serious accident, and after the accident there might not have been enough left of the boiler to determine the cause.

The two rejected boilers are still waiting for some purchaser who will not know the difference between a high-grade boiler and an inferior one.

Engineering Progress in the U. S. Navy

SYNOPSIS—For the conditions of service under which the American battleship fleet operates, the reciprocating engine is more efficient. In ease of upkeep, weight and space required it has the advantage and in reliability at high powers it is on a par with the turbine.

In his paper on the above subject read before the Society of Naval Architects and Marine Engineers at the New York meeting, Captain C. W. Dyson made a comparison of propelling machinery for heavy vessels of moderate speed. In this comparison were included reciprocating engines; steam turbines of the impulse and reaction types, and a combination of the two; also combinations of reciprocating engines with turbines. The relative values of turbine reduction gear, electric propulsion and internal-combustion engines for propulsion were not dealt with, as final operating data had not as yet been secured.

Speed, Horsepower and Fuel Consumption

To assist in judging the three methods of propulsion a comparison of the performances of the dreadnoughts "Delaware," "North Dakota," "Utah" and "Florida" was made, including trials in preliminary acceptance and in actual service. The "Delaware" is equipped with reciprocating engines and the other three vessels with turbines.

Due to difference in displacements and in appendages the effective horsepower required to give the "Delaware" a speed of 21 knots will give the "Florida" and the "Utah" 20.82 knots, and the "North Dakota" 21.1 knots; at 12 knots for the "Delaware," the equivalent speed of the "Florida" and the "Utah" is 12.17 knots and of the "North Dakota" 12.1 knots. Assuming that shaft horsepower is approximately 92 per cent of indicated horsepower in large, well designed reciprocating engines, and reducing the indicated horsepower of the "Delaware" to shaft horsepower, the following table of comparison results:

	"Delaware"	"North Dakota"	"Utah"
Speeds of equal e.hp.	21	21.1	20.82
I. hp. for this speed	23,400	.....	.....
S. hp. for these speeds	21,528	27,150	25,000
Propulsive coefficient equals (per cent.) e.hp. ÷ s.hp.	71.76+	56.8+	61.8+
Cruising speeds of equal e.hp.	12	12.1	12.17
I. hp. for this speed	3,600	.....	.....
S.hp. for these speeds	3,312	3,825	3,975
Propulsive coefficient equals (per cent.) e.hp. ÷ s.hp.	74+	64.1+	61.6+

While the "Florida" curve is shown in Fig. 1, that vessel is not included in the above table, as the weather conditions during her standardization trials were unfavorable and the efficiency of the propellers fell off greatly.

In Fig. 2 a comparison is made of the pounds of fuel per knot required at different speeds by the four dreadnoughts. In this figure is also shown a curve of excess fuel for the "Utah" over that required for the "Delaware," all the curves being drawn with effective horsepowers as abscissas. For the effective horsepower value required for 12 knots speed of the "Delaware," the "Utah" requires, by these curves, 22 per cent. more fuel. From the steam logs of the two vessels, the average excess fuel consumption of the "Utah" over that of the "Delaware" at 12 knots is 20 per cent., thus corroborating the results.

At the effective horsepower value required for 21 knots by the "Delaware," the "Utah" requires 1.015 times as much fuel as the "Delaware," a difference so slight as to be negligible. From the above results, it appears justifiable to decide as follows:

Should the duties of a vessel be such that she be required to steam for long periods and long distances at speeds much lower than her designed maximum speed, a less fuel expenditure per day will be required, and consequently a greater cruising radius will be obtained and less frequent recoaling necessitated should reciprocating engines be fitted rather than turbines for propelling purposes.

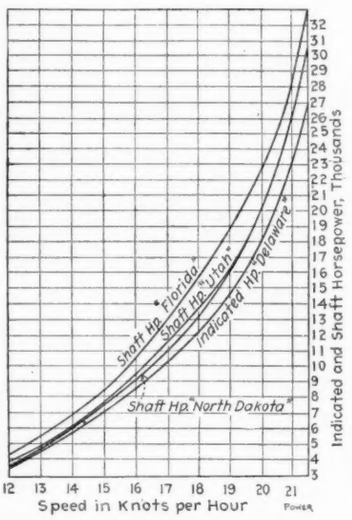


FIG. 1. HORSEPOWER-SPEED CURVES

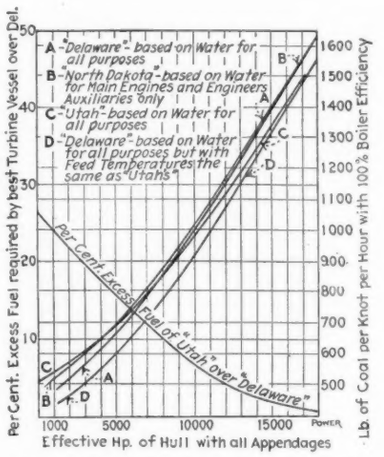

A "Delaware" based on Water for all purposes
B "North Dakota" based on Water for Main Engines and Engineers Auxiliaries Only
C "Utah" based on Water for all purposes
D "Delaware" based on Water for all purposes but with Feed Temperatures the same as "Utahs"
Per Cent. Excess Fuel of "Utah" over "Delaware"
Per Cent. Excess Fuel required by best Turbine Vessel over Del.
Lb. of Coal per Knot per Hour with 100% Boiler Efficiency
Effective Hp. of Hull with all Appendages
POWER

FIG. 2. HORSEPOWER-COAL CURVES FOR DIFFERENT SPEEDS

Should, however, the vessel operate from a fixed base, only doing sufficient cruising to insure that the machinery is kept in efficient condition in readiness for forced runs to any threatened point, the value of fuel economy at low speeds becomes minimized and, where the maximum speed of the vessel does not exceed 21 to 22 knots, either turbines or reciprocating engines may be used, the choice being dependent upon other factors than economies, which are practically equal at these speeds.

For the conditions of service and the fuel capacity entailed under which the American battleship fleet operates, the reciprocating engine is preferable to the turbine as a propelling engine at the present stage of turbine development. The Navy Department is, however, thoroughly alive to the advantages to be gained by adopting rotary in place of reciprocating motion in the main propelling machinery of the heavy vessels of the fleet, and while recognizing the present advantages held by the reciprocating engine in the matter of economy at low fractions of designed power, holds itself ready to discard the reciprocating engine as soon as the turbine designers can demonstrate by actual performance that their claims as to equality of economy at low powers with the older machine have been realized. It was with this object in

view that the department decided to install impulse turbines in the "Nevada."

Ease of Upkeep of Machinery

The claim is frequently made by the turbine advocates that while the reciprocating engine, when new, is undoubtedly more economical than the turbine at small fractions of designed power, this advantage is soon lost in active service, due to excessive wear of piston and valve rings causing heavy leakage of steam. The turbines, not being subject to such frictional wear, would, on the other hand, retain their original economy indefinitely.

Practical experience with both types of engine in actual service comes very far from justifying this conclusion. In fact, with intelligent supervision, the reciprocating engine, particularly since forced lubrication has been applied, holds its superiority continuously.

When reciprocating-engine vessels visit the navy yards for their regular overhaul, the work to be done on the main engines is practically nil, as the machine shops and foundries of the battleships are of ample capacity to take care of all repairs that may be necessary except such as the fitting of a new cylinder or the repair of a fractured bedplate. The above remarks apply only, however, to ships fitted with forced lubrication, where the wear of bearings and journals has been practically eliminated. In a letter from the senior officer of the "Delaware," the following statements occur:

"Between July 1, 1910, and July 10, 1912, the "Delaware" has steamed 54,627 miles (knots) without a hot bearing.

"About the only wear on the brasses on the forced lubrication system is on the crossheads first, then guides and then crankpins. The wearing away of the piston rings apparently starts all the other wear."

That is, keep the pistons in line and the wear on the running parts is practically eliminated. The experience of the "Delaware" is corroborated by the experience of every reciprocating-engined vessel of the fleet to which forced lubrication has been applied. This system not only insuring efficient lubrication, but also reducing wear on all running parts, decreases the initial friction of the engines and reduces to a minimum all shock on crankpins, crossheads and main bearings, thus preventing hammering out of the white metal and wearing down out of line.

With the turbine, the case is quite the opposite. Fully 99 per cent. of the troubles that occur are internal troubles, and consist of erosion of blades and nozzles, stripping of blading, heavy corrosion of rotors, diaphragms and turbine wheels, causing destruction of balance. All of these troubles require a perfectly smooth haven in which to make repairs, and the majority of them require dock-yard facilities.

In the cases of the main engines of the three scout cruisers "Birmingham," "Salem," and "Chester," the "Birmingham," with reciprocating engines, has always been ready for service, while her two sister ships have been repeatedly laid up at the yards for overhaul of the main turbines. Evidence of experience leads to the conclusion that a battleship fitted with reciprocating engines for propelling purposes is much less apt to be forced off her station by necessary repairs to her engines than is one fitted with turbines.

Reliability at High Powers

From the natures of the two machines, it would appear safe to decide this condition as being distinctly in favor of the turbines, as this type of engine is completely free from all reciprocating parts held together by bolts and nuts. Experience with the "Delaware's" engines, however, lead to the conclusion that where proper care is taken to lock all nuts securely, and to effectively protect the engines against the shocks of reversal of direction of motion, the reciprocating engine can, even here, be regarded as nearly on a par with the turbine in reliability. The full-power 24-hr. run of the "Delaware," made without preparation immediately after her arrival home from Chile, demonstrates this reliability of the present type of battleship engines very thoroughly. The vessel put to sea, and upon getting well clear of the land a full-power run of 4-hr. was started, during which time the vessel averaged 21.86 knots per hour. Without intermission the vessel continued on for 20 hr. longer, averaging for the full 24-hr. a speed of 21.3 knots, the ship automatically slowing down as the fires became dirty and the personnel fatigued. Upon the completion of the trial a radiogram was received from the commanding officer of the vessel reporting that not the slightest disarrangement had occurred to either the main engines or the auxiliary machinery, and that she was ready for immediate service.

Minimum Weight and Space Required

As already shown, the total heat units required to be absorbed by the boilers, both for Parsons turbines and for reciprocating engines, with battleships of the speed and power that now exist, is practically the same in both cases at full power. This indicates that, for existing conditions, nothing can be saved in the boiler room weights or space by adopting turbines, as the same boiler power is required in the two cases.

In the engine rooms, for these powers, however, the reciprocating engine has a decided advantage in both weight and space required. In the "Delaware," "North Dakota," and "Utah," the engine room weights and space required are as follows:

	"Delaware"	"North Dakota"	"Utah"
Engine room weights, dry tons.....	728.26	731.23	864.69
Engine room weights, wet tons.....	773.26	785.93	919.80
Engine room, length, ft.....	44	44	60
Engine room, total width, ft.....	50.5	50.5	51
Engine room, sq.ft. floor space.....	2222	2222	3060

While the turbines of the "North Dakota" appear to be about on an equality with the reciprocating engines of the "Delaware" in the matters of weight and space, these turbines were extremely uneconomical. Modern turbines of this type would require an engine room more nearly equal in length to that of the "Utah," and the engine-room weights would be considerably increased.

While the reciprocating engine has a decided advantage in the features of weight and space required, under present conditions, these advantages would disappear should the necessary power to be developed be increased considerably above what is now asked for, and the advantage would rest with the turbine. Should such an increase of power be called for in future designs, or should the ordinary cruising speed be made considerably higher than now used, the Navy Department would undoubtedly abandon the reciprocating engine and adopt one of its rotary rivals for the propulsion of its capital ships.

Efficient Propellers for Maneuvering

In considering this condition, the relation of the backing power as compared with the maximum full power ahead, and the time required from full speed ahead until the vessel was dead in the water, was taken as a basis of comparison, which resulted in favor of the reciprocating engine.

Dividing the backing power by the ahead power of the "Delaware" gave 87.5 per cent. as compared to 35.7 per cent. for the "Utah." These results are corroborated by the destroyers and other vessels of the navy.

In judging the steadiness of the hull as a gun platform as affected by machinery, it seems only fair to base the decision upon the results of target practice of the vessels in service. If this is done, the decision could be given to the reciprocating type of machinery, as the "Delaware" has just won the championship of the battleship fleet, with the "Colorado," another reciprocating engine vessel, standing second on the list. From these results it appears reasonable to state that, with well balanced reciprocating engines, no ill effects on gun fire should be expected.

Basing the choice between reciprocating engines and turbines for battleship propulsion under existing conditions of speed and power, the advantage appears to rest most decidedly with the reciprocating engine.

Combination Systems

In the search for economy of propulsion through a wide range of speeds, various combinations of reciprocating engines and turbines have been proposed, both by the Bureau of Steam Engineering and by the shipbuilders, but only one of the systems has as yet been authorized, and that one is for destroyers. It has not yet been tried out in service, but preliminary shop tests show a good gain in economy of the main propelling engines at cruising speeds. This system, as applied to the destroyers, depends entirely for its gain upon the greater efficiency of the reciprocating engine at the higher steam pressures over the efficiency of high-pressure turbines of the reaction type and the high-pressure nozzles of the impulse type of turbine, no advantage being gained from increased efficiency of propellers, as the reciprocating engines are on the same shafts as the turbines. From some points of view this combination is undesirable, and the gain in service must be considerable to justify its retention.

With the other combination systems proposed, calculations indicate that if the propulsive efficiency counted upon can be obtained, these systems will all be very much more efficient than either a straight turbine or straight reciprocating engine drive at maximum power, will hold a big advantage over the straight turbine drive through all ranges of power, and will hold its advantage over the straight reciprocating engine drive until a minimum speed of about 11 knots is reached, when the efficiencies become equal.

The "if" exists, however, and is caused by the danger of the currents thrown to the rear by the big reciprocating-engine screws seriously affecting the rate of feed and direction of flow of water to the turbine propellers. In addition, there may possibly be another source of loss due to heavy leakage of steam through the large change valves which must be fitted to control the paths of flow of the exhaust steam from the reciprocating engines.

In all of these systems, to adapt them to naval requirements, it is necessary to exhaust from the low-pressure cylinders of the reciprocating engines at a pressure of not less than 25 lb. absolute, when this engine is operating at full power, and to bypass as few of the stages of the turbine as possible in order to obtain an increased economy of propulsion through a large range of powers.

[The balance of the paper, which will be abstracted in a later issue, was devoted to turbine changes, improvements in reciprocating engines tending towards increased economy and reduction in weight and a discussion of oil fuel.—Editor.]

Worthington Turbo Blowers and Compressors

Turbo-blowers and compressors have certain advantages over reciprocating compressors in various fields. In consequence of the demand growing out of this fact the firm of Henry R. Worthington, Harrison, N. J., made a comparative study of the different apparatus of this type manufactured throughout the world. This investigation covered operating efficiency and reliability as well as general design and economy, and led to the conclusion that the product of Pokorny & Wittekind, of Frankfort-on-the-Main, Germany, pioneers in this field, had shown the best results in every respect. Early in 1911, therefore, the rights for the manufacture and sale on the American Continent and in the Hawaiian and Philippine Islands, of the full line of turbo-compressors so successfully developed, were acquired by Henry R. Worthington. This firm is now in position to build and supply such apparatus for all ranges of capacity and pressure ordinarily covered by reciprocating compressors.

Turbo-blowers and compressors are quite similar, except in the matter of water jacketing and the number of stages, and are very similar in construction and principle to centrifugal pumps. The differences between centrifugal pumps or blowers and compressors are principle such as are required to adapt the compressors for handling light and elastic fluids, instead of the heavy and almost incompressible water. The success of this apparatus, however, is largely a question of engineering and shop experience and development.

Fig. 1 illustrates an experimental turbo-blower built and installed at the Harrison works for the special purpose of testing and checking the performance of the apparatus. The machine is shown on the testing floor driven by a steam turbine through a torsion dynamometer. Fig. 2 shows an end view of the testing set looking toward the blower. Fig. 3 shows a motor-driven turbo-blower of the type used for capacities of from 10,000 to 30,000 cu.ft. of air per minute at 15 lb. gage pressure. Fig. 4 is a view of a turbo-compressor driven by a mixed-pressure turbine and having a capacity of 10,000 cu.ft. of air per minute against a presure of 1000 lb.

Centrifugal and turbo-blowers and compressors consist simply of a stationary casing inclosing a rotating element supported in bearings. The casing may contain one or a number of impellers, depending upon the pressure desired. The impellers, carried upon a shaft equipped with a thrust bearing, constitute the rotating element. The casing has a suction and a discharge opening and is divided into as many cells or stages as there are impellers. Leakage about the shaft and between the stages is prevented by labyrinth packings.

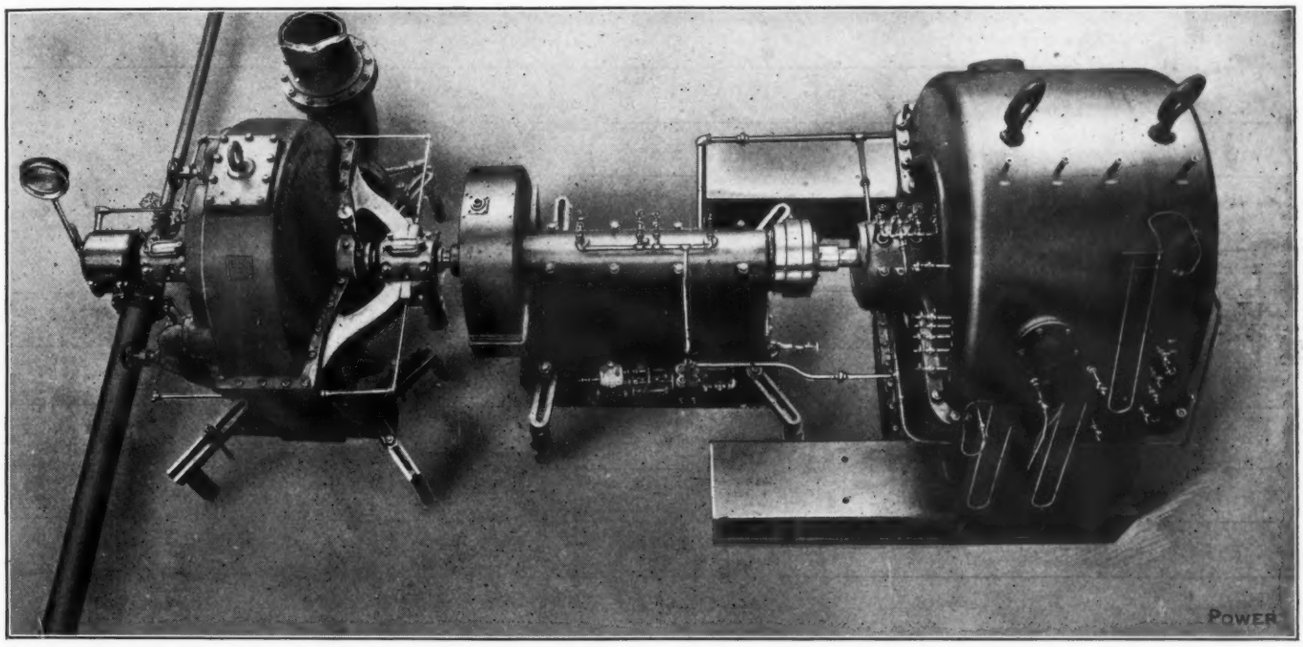


FIG. 1. BIRDSEYE VIEW OF AN EXPERIMENTAL TURBO-BLOWER UNDER TEST AT THE WORTHINGTON WORKS

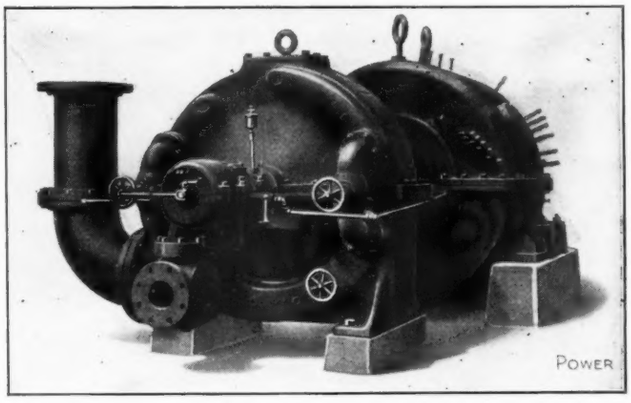


FIG. 2. END VIEW OF THE TURBO-BLOWER

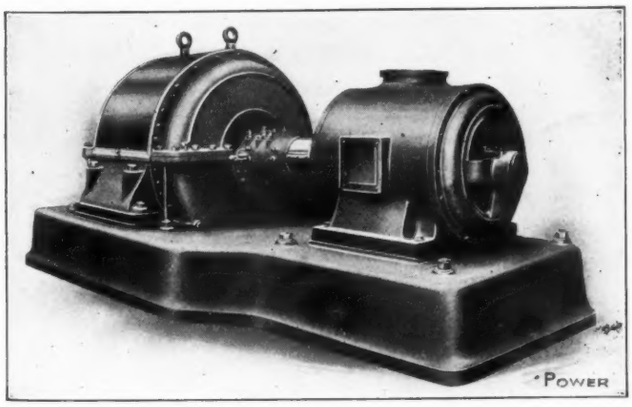


FIG. 3. TURBO-BLOWER

The air enters the suction pipe at low velocity and is guided to the impellers by directing vanes; in passing through the impellers the pressure and velocity are increased. Leaving the impellers the air is received by a ring of diffusion vanes which convert a large part of the velocity into pressure and greatly reduce the leakage losses. Upon leaving the first set of diffusion vanes, the air at reduced velocity, flows by easy curves to the influx chamber preceding the next impeller. This process is repeated for each stage until the exhaust is reached.

A light and compact prime mover can be used as, owing to the high rotative speeds, the prime mover and the compressor can be directly connected; moreover, whether the prime mover is an electric motor, or a high-pressure, an exhaust or a mixed-pressure turbine, it can

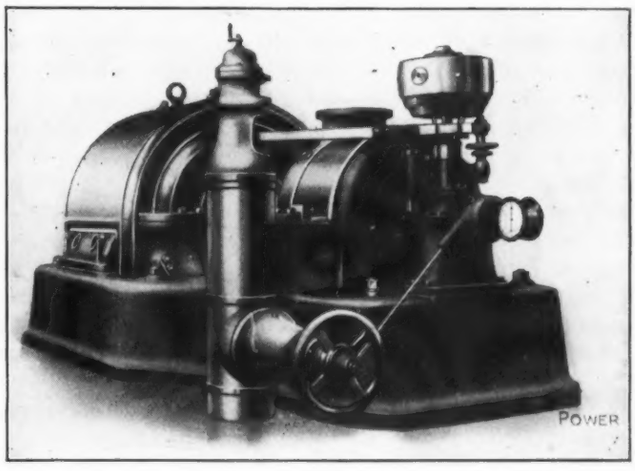


FIG. 4. TURBO-COMPRESSOR

be operated at its most desirable speed. High efficiency is maintained throughout the life of the machine.

Other advantages of turbo-compressors over other types may be summarized as follows: Low first cost; minimum attendance; continuous even flow of air; compact construction; light weight; small foundation and installation expense; minimum upkeep charges; simplicity of construction, insuring ease of operation and minimum of attention; long life, due to few rubbing parts and rugged construction; absence of valves, which are troublesome and cause loss of efficiency; low friction loss, due to the few rubbing parts; absence of packing trouble; absence of vibration, and economy of lubricants.

ELECTRICAL DEPARTMENT

Ground Detectors

By R. L. Mossman

The diagrams show the various methods of connecting lamps and voltmeters as ground detectors, also the electrostatic detector as used on high-voltage alternating-current circuits. A ground detector is an important instrument on a switchboard and should be used frequently; when a ground shows on a line it should be cleared as soon as possible, for if the line of opposite polarity should ground a short circuit and interruption of the service would result.

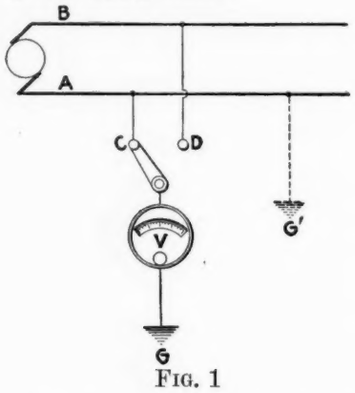


Fig. 1

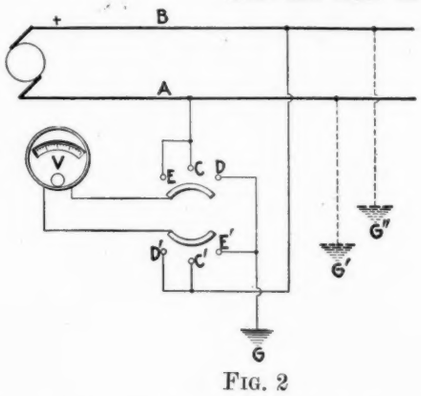


Fig. 2

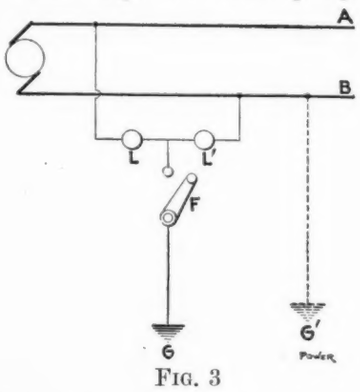


Fig. 3

A voltmeter makes a very good ground detector, because it not only indicates whether a ground is present, but by its deflection shows whether the path of the current to the ground is one of high or low resistance. Fig. 1 shows one way of connecting a voltmeter on a two-wire circuit. If the line *A* should be grounded as indicated by the dotted line at *G'* and the switch placed on *C* no deflection would result. If the switch is moved to *D* current will pass from line *A* through the ground on the line through the voltmeter to point *D*, thence to line *B*, thus completing the circuit. When the deflection is obtained on *D* it shows that line *A* is grounded; when obtained on *C* it shows line *B* is grounded.

If the ground is of high resistance the deflection will be small, if of low resistance it will be large. In using a voltmeter connected in this way, it must have its zero point in the center of the scale, as the current will flow through it in the opposite direction on point *C* from what it will on point *D*. A voltmeter having its zero point at the left of the scale can be connected as in Fig. 2 which is a better method. It can then be used either as a voltmeter or as a ground detector. When the switch is in position *CC'* the voltmeter is connected directly across the line and gives the voltage on the system; when in position *EE'* it will indicate a ground on line *B*, as at *G''*. When in position *DD'* a deflection will indicate a ground on the line *A* as *G'*.

Fig. 3 shows a common arrangement where two lamps *L* and *L'* are used in series; each lamp should be for the same voltage as that of the circuit, which will cause them to burn half of their rated candlepower. A connection is made to ground through switch *F*. When contact is made at *F* and there is no ground on either line the brilliancy of the lamp will not be altered. If there is a ground on *B*, as at *G'*, lamp *L'* will go out or burn dim and *L* will burn brighter according to the resistance of the ground; if the ground is on *A*, *L'* will burn brighter. This is a simple and very good ground detector when a voltmeter is not available.

Fig. 4 shows a lamp ground detector suitable for a three-wire low-tension system. Three lamps, *L*, *L'* and *L''*, are connected in series across one side of the system, and a ground connection is made at *K*. When all three lines are clear of grounds the lamps will burn equally when *K* is closed. If line *C* becomes grounded at *G'*, *L* and *L'* will go out or burn down, and *L''* will become brighter. If line *B* is grounded *L''* will become dim while *L* and *L'* become brighter. If the ground is on *A* all the lamps will become brighter, because all will get the full voltage, *L''* being across *A*, *B*, and *L* and *L'* in series across *AC*. These detectors are applicable more particularly to low-tension direct-current installations.

In Fig. 5 is shown a voltmeter detector on a three-phase system, the voltmeter being connected through a

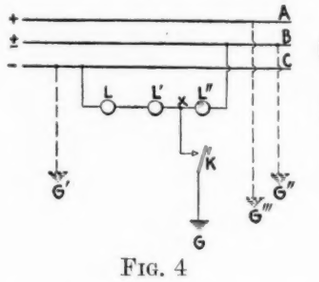


Fig. 4

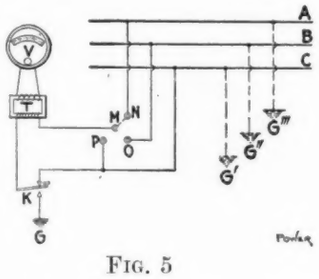


Fig. 5

transformer *T*. A plug switch is used to connect across from *M* to *N*, *O* and *P*. When across *M* and *N* and the key *K* is pressed, it will show a ground on *B* or *C*; when across *M* and *O*, a ground will show on *A* or *C*; when across *M* and *P*, it will show a ground on *A* or *B*.

Electrostatic ground detectors are much used on high-tension, alternating-current switchboards. They have the advantage that they require no current for their operation and may be left connected to the circuit all the time, thus indicating a ground as soon as it occurs. They also give an indication without its being necessary to make an

actual connection between the line and the ground, as is the case with all the detectors previously described. The principle of a Stanley electrostatic ground detector is illustrated in Fig. 6. This is especially adapted to high-tension, alternating-current lines, because the instrument is not in actual connection with either of the lines.

The fixed vanes, *M, N, O* and *P,* are connected in pairs as shown. The movable vane *V* is connected to the ground at *G,* and is held in the central position as shown

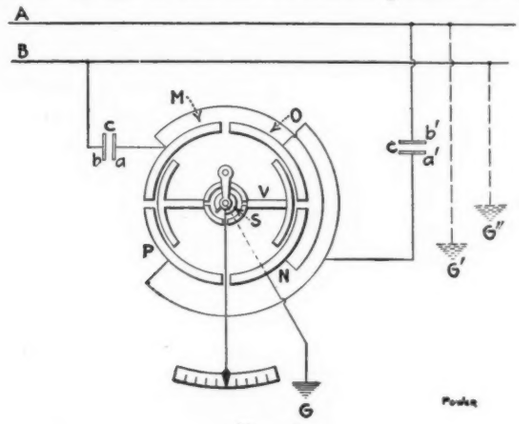


FIG. 6

by the small spiral spring *S*. The pairs of fixed plates are not connected direct to the lines, but are attached to plates *a a'* of two small condensers which consist simply of two brass plates, mounted in hard rubber but separated from each other. Plates *b* and *b'* are connected to the lines. When no grounds are present, *MN* and *OP* become oppositely charged by reason of charges induced on the plates *a a'* by plates *b b',* the forces acting on vane *V* are therefore equal and opposite. Now assume line *B* to be grounded at *G''*. This is equivalent to connecting

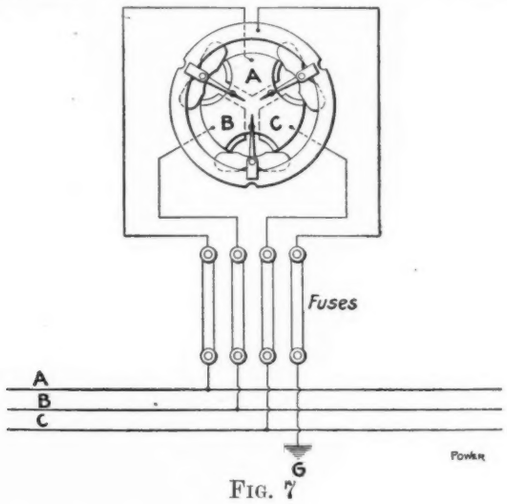


FIG. 7

vane *V* to line *B* and *V* takes up a charge similar to *O* and *P,* hence, it is repelled by *O* and *P* and is attracted by *M* and *N,* thus giving a deflection. If *A* becomes grounded, a deflection in the opposite direction is obtained.

Instruments of this kind can, of course, only be used where the voltage is fairly high, as the electrostatic forces produced by charges due to low voltages would not be large enough to operate an instrument unless it were made much too delicate to be of practical use in a power house. In most electrostatic detectors the lines are connected directly to the fixed sectors, and the condensers *cc* are omitted.

Fig. 7 shows a General Electric three-phase electrostatic detector without condensers. It is practically three single-phase detectors combined in one instrument. When no ground exists, the three needles point toward the center. When a ground occurs on one of the lines, the two adjacent needles are deflected toward the segment to which the grounded line is connected. Should a ground occur on two lines the needle between the segments connected to the grounded line will be deflected toward the one having the lower resistance ground and the two remaining needles will be deflected toward the grounded segments.

The Turbo Converter

A novel machine was described by F. Creedy at a recent meeting of the British Institution of Electrical Engineers. It is intended to overcome the difficulty of commutation often troublesome in high-speed turbo-generators of large output, which fact led H. M. Hobart to propose that when continuous current is required, a turbo-alternator be used in conjunction with a rotary converter. Mr. Creedy, in fact, follows this suggestion to the extent of using a turbine to drive a converter, but not a rotary converter of the ordinary type; instead, he employs a "motor-converter," very similar to the machine known by that name and invented by Messrs. Bragstad and La Cour, which has become widely used in England on account of its cheapness and efficiency.

In the motor-converter there are really two machines—an induction motor and a rotary converter driven by the motor. The winding of the rotor of the motor is connected by conductors through a hollow shaft with the armature of the converter, at suitable points, and about half the power is transmitted to the converter through these windings, while the other half is transmitted mechanically through the shaft, driving the converter as an ordinary continuous-current generator. The result is that the combined machine runs at half the speed at which the motor would run if it were not coupled to the converter, and possesses other advantages which, however, need not be mentioned here. Mr. Creedy availed himself of the reduction in speed to permit the commutator of the continuous-current part of the machine to work under better conditions than obtain in the case of a dynamo directly coupled to a turbine.

In the turbo-converter, the induction motor is replaced by an induction generator, the squirrel-cage rotor of which is mounted on the shaft of the turbine and therefore driven by the latter. This construction is particularly favorable, as the rotor can be very strongly built, and is easily capable of withstanding the high speed of rotation, sometimes as high as 3000 r.p.m. The "primary" of the generator, as it is called, though the name is not very appropriate, revolves round the "secondary" or rotor, but is in no way connected to the turbine shaft; it is carried on the shaft of the converter, as shown in Figs. 1 and 2. The primary is driven by the torque due to the currents circulating in the secondary and primary, and the currents generated in its windings are led by insulated conductors through the hollow shaft to the armature of the continuous-current part of the rotary

converter, in which they are converted to continuous current. The torque which drives the primary is transmitted mechanically through the shaft to the armature also, and drives the latter as a generator. Thus the whole output of the turbine, less losses, appears on the continuous-current commutator.

Now, the speed of the converter armature, as in the case of the motor-converter previously referred to, is only half

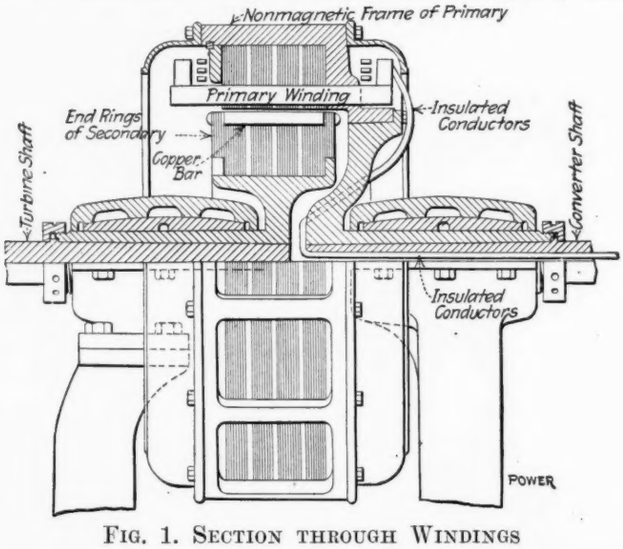


FIG. 1. SECTION THROUGH WINDINGS

that of the rotor or secondary on the turbine shaft, if the alternating- and direct-current machines both have the same number of poles; and it may be slower still if desired, the ratio of speeds being the same as the ratio of the number of poles on the induction generator to the number of poles on both machines added together. Thus with a two-pole induction generator and an eight-pole converter, the armature of the latter would run at one-fifth the speed of the turbine. This high ratio, however, would entail increased cost of construction. It will be

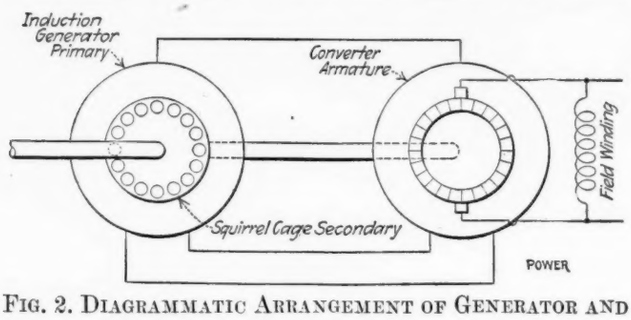


FIG. 2. DIAGRAMMATIC ARRANGEMENT OF GENERATOR AND CONVERTER

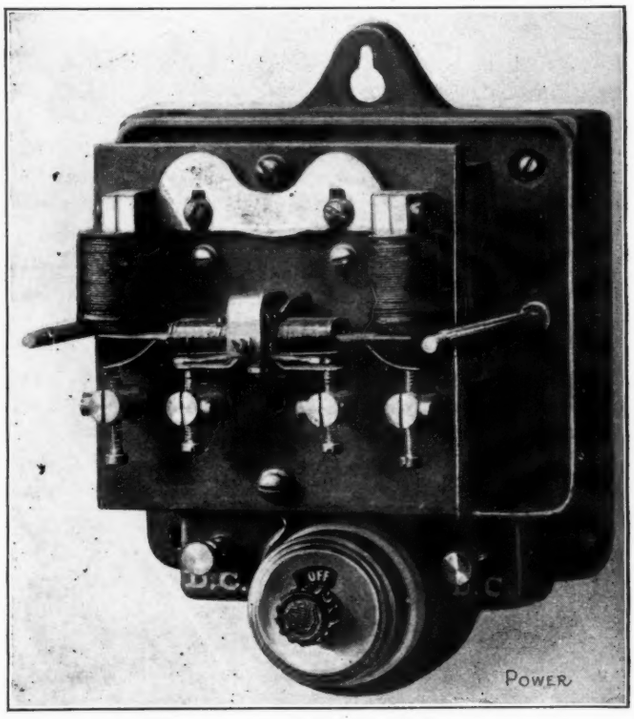
noticed that the design of the induction generator has been so contrived as to reduce the amount of overhang of the rotors to the smallest possible amount, and the joints between the hubs and the two shafts have been carried through the bearings for the same reason. The design of the converter portion of the set, however, is on the usual lines.

The advantage of the system as compared with that of Mr. Hobart is that, whereas in the latter the alternator and the rotary converter would each have to be capable of dealing with the whole output of the turbine, in the Creedy system each machine need only be large enough to carry half the total output.

Rectifier for Charging Three-Cell Batteries

The rectifier illustrated herewith is intended for charging three-cell lead storage batteries, such as are used for automobile or gas-engine ignition and for lighting automobiles from an alternating-current circuit. It is of particular benefit to the motor-car owner who has a three-cell battery equipment, as it enables him to charge his batteries at home at small expense and with no trouble whatever, directly from his lighting circuit.

The apparatus consists essentially of a polarized relay acted upon by two alternating-current magnets so that it vibrates in synchronism with the alternations of the current, and arranged to reverse the connection of the circuit as the current reverses. The vibrating arm is magnetized by current from the direct-current side, so that one end is permanently North and the other end permanently South, depending on the way the battery is connected. The two stationary electromagnets are wound so that their lower ends are of the same polarity at each instant. When the alternating current is in one direction the lower poles of both stationary magnets are North, attracting the south end of the vibrating arm



RECTIFIER WITH COVER REMOVED

and repelling the north end. This connects the alternating-current to the direct-current circuit in one direction. When the alternating current reverses, the pole of the alternating current magnets become South, attracting the north end of the vibrating arm and repelling the south end. This reverses the connection of the alternating-current to the direct-current circuit, but as the direction of the current has also reversed, the current flows into the direct-current circuit in the same direction as before. The reversal of the connections thus takes place every time the current reverses, so that the result is a pulsating direct current. A transformer reduces the voltage to the proper value.

GAS POWER DEPARTMENT

Ignition from Dry Cells

By A. L. Brennan, Jr.

Although manufacturers of storage batteries have made progress during the past few years in raising their product to a high standard of efficiency, still many members of the old school adhere to the notion that dry cells are in many respects superior to any other chemical means of producing a primary current. This idea has been handed down from one gas-engine operator to another with the result that it would now be quite out of the question to dispense with them.

A few years ago when many operators attributed the majority of their engine troubles to the electrical source, the batteries were not at fault in every instance, but nevertheless, were far from perfect. This, however, does not hold true of the present-day cells, although they do occasionally give trouble in the hands of inexperienced operators. With this in mind the following notes have been prepared to enlighten the inexperienced sufficiently to understand the why and wherefore of dry cells.

There are several features to be considered when employing dry cells to furnish a primary current, which have to do directly with the cells themselves, while, on the other hand, there are other points to be looked after, which indirectly interfere with maintaining sparking efficiency on a low rate of current consumption.

In the first place, the cells should be kept in a dry place and fully protected from contact with any other element. The wiring should be of ample size, all connections firm and the contact surfaces of the terminals sufficiently large to cause no hindrance to the current. This feature in the wiring is often overlooked. Some wire is composed of strands which are apt to become separated, some of them breaking off, thus reducing considerably the carrying capacity of terminals of the wire; also the switch contacts may be at fault.

Present competition has rendered the production of coils and other parts of the ignition system far in advance of what they were a few years ago, and at present the several appliances to be had are representative of the latest means of combining high efficiency in conjunction with low discharge rate from the battery. These conditions, however, are entirely in the hands of the operator. He may have at his disposal a thoroughly modern coil but, through poor adjustments or other causes, the results may be very poor. On looking into the matter it may be found that a small wire offering considerable resistance to the current is the cause of apparent battery exhaustion—a cause in no way allied to the source of the primary current.

Coil Adjustments

Faulty coil adjustments are also largely responsible for supposed battery faults. By increasing the tension on the vibrator the demands made upon the battery will be greater and in many cases with no material advancement in the output of the engine. It will be found that having obtained a spark of sufficient density to ignite the compressed mixture and the motor is once in operation that the tension on the trembler can be materially altered without apparent change in the running—either increasing or decreasing the amount of energy taken from the battery. This goes to show that to get positive ignition, but at the same time to utilize as little battery current as possible, the several component parts of its ignitor system will have to be adjusted to suit one another.

Considering a spark plug, for example, much is heard about keeping the parts of a spark plug tightly assembled, the points clean and the connections of the secondary wires secure; but what distance apart should the points be set? Some authorities recommend $\frac{1}{16}$ in., some less and others more, and the query naturally arises—who is right? It may be said that all are correct as far as the actual operation of the motor is concerned, for with adequate coils and batteries the varying spark gaps can be easily taken care of, but this discrepancy of spark-plug adjustment is accompanied by material loss in some cases and invariably the battery is held responsible.

To correct this very prevalent fault, the spark-plug gap should be as short as possible; that is merely long enough to produce positive firing. Also, the coil should be adjusted to its minimum rate of current consumption, which adjustment can only be carried out when the motor is in operation and working under its ordinary load. Positive and ample contacts at all times are necessary.

On testing a spark plug under ordinary conditions (atmospheric pressure) it is found that much less electrical energy is required than that necessary when the plug is in the cylinder and the spark occurs under the high compression pressure of the combustion chamber.

This point can be readily proved by disconnecting the wire at the plug, unscrewing the plug from the cylinder, connecting the wire as before and placing the threaded section of the plug on the cylinder, then turning the engine over to the firing point, having the switch in the battery contact position. A buzz will be heard when this point has been reached, providing the trembler is adjusted approximately, if not, watch the contact points at the timer, for when they are together the motor is on the firing point.

If this method cannot be followed observe the marks on the flywheel or test the piston with a wire to find when the top center on the compression stroke is reached. When the firing point is found, adjust the coil to produce a spark with the least possible tension on the trembler. Having completed this step, insert the plug in the cylinder, wire and attempt to start. It will be found difficult, however, to get the motor to pick up until the tension on the vibrator has been materially increased. This experiment fully bears out the point that more electrical energy is required to produce an arc under high pressure than under ordinary conditions.

Bearing this point in mind not a few conceive the idea that gas could be more readily ignited at low pressures,

but this is an erroneous notion, for gas is far more susceptible to ignition when compressed. Thus it is found that although it takes decidedly more electrical energy to produce an arc in high pressure, still there is not such a demand made upon the battery as in the case of attempting to operate a motor which is not capable of producing high compression.

Defective mixtures are another element which sometimes very materially affect consistent engine operation and lead one to suppose the ignition is at fault. In cases of this kind one of the first remedies suggested is a tighter adjustment of the contact points which in some cases may appear to better the conditions, but the motor should operate without this latter adjustment which can only result in overtaxing the battery to a certain degree.

Recuperation of Battery

The points already considered are those dealing with how to minimize and maintain efficient operation on a low expenditure of battery current and although of great importance there are other features of equal value.

For instance the time allowed for recuperation is also to be considered if lasting efficiency is desired from the cells. It is not altogether feasible to suggest any strict rules to be followed in this respect, for much depends upon the method employed in connecting the cells. Assuming, however, that six cells are used in series it will be found in practice that continuous operation rapidly decreases the amperage and that considerable time must be allowed for recuperation. To remedy this defect two methods are offered. The first is to use two sets of cells of the required voltage alternately. A two-way switch should be employed and during operation switch from one set to the other about every two hours. This method will greatly increase the life of the cells and insure high efficiency.

The second method is to connect the cells in series-multiple which is perhaps superior to the first. First connect the cells in series in numbers sufficient to give the required voltage and place these sets of four to six cells in multiple by connecting the negative posts together and also the positive posts. Cells connected in this manner give the lowest rate of discharge in amperes per cell at an increased ratio according to the number of series sets in line. But it is not a good plan to carry this method to extremes, for the deterioration while not in operation is considerable; besides the cash investment and space required should also be considered.

Alcohol vs. Gasoline Engines

A few years ago the alcohol engine was much discussed in engineering circles and many went so far as to predict that it was only a matter of a few years before it would entirely displace the gasoline engine. Contrary to these expectations, however, the past four or five years have witnessed unprecedented advances in gasoline engine development; not only have they been greatly improved in design and construction but the number in use has increased enormously. In striking contrast to this, the alcohol engine has practically dropped out of sight, and with the exception of a few laboratories is nowhere to be found in actual operation.

Recently we have received a number of inquiries, from readers, as to the cause of these conditions and as to the comparative performances of gasoline and alcohol engines. Perhaps one of the most exhaustive investigations into this subject was that conducted by Messrs. Strong and Stone for the Bureau of Mines. This investigation extended over several years and the results have recently been made public in bulletin No. 43.

Without going into the details of the tests but quoting in substance from the report, it says:

The lower heat value of completely denatured alcohol averages 10,500 B.t.u. per pound, or 71,900 B.t.u. per gal.; whereas, the lower heat value of gasoline having a specific gravity of 0.71 to 0.73 averages 19,200 B.t.u. per lb. From this it will be seen that the best value of 1 lb. of alcohol is approximately six-tenths that of gasoline.

However, 1 lb. of gasoline requires about twice the weight of air for complete combustion that is required by 1 lb. of alcohol. Hence, the heat value of 1 cu.ft. of an explosive mixture of alcohol vapor and air having theoretically just sufficient air for complete combustion is approximately equal to that of 1 cu.ft. of a similar mixture of gasoline vapor and air—about 80 B.t.u. per cu.ft.

Explosive mixtures of alcohol vapor and air in an engine cylinder can be compressed to much higher pressures without preignition than explosive mixtures of gasoline vapor and air. The maximum compression that can be used in an engine without causing preignition depends on the quality of the explosive mixture, the design of the engine, and the speed at which it is operated.

For 10 to 15-hp., four-stroke-cycle stationary engines a compression pressure of about 70 lb. per sq.in. above atmospheric pressure was found to be the maximum that could be used for gasoline mixtures and about 180 lb. the maximum for alcohol engines, without causing preignition.

The maximum compression that could be obtained without causing preignition was in each case found to be the most advantageous with regard to fuel economy.

A gasoline engine having a compression pressure of 70 lb., but otherwise as well suited to the economical use of denatured alcohol as gasoline will, when using alcohol, have an available horsepower about 10 per cent. greater than when using gasoline. When the fuels for which the respective engines are designed are used to the same advantage, the maximum available horsepower of an alcohol engine having a compression pressure of 180 lb. is about 30 per cent. greater than that of a gasoline engine having a compression pressure of 70 lb., but of the same cylinder diameter, stroke and speed. Moreover, an alcohol engine can, in general, be so designed and constructed as to equal the gasoline engine in adaptability to service, and when working at the degrees of compression best suited to the fuel supplied, requires about equal volumes of gasoline and denatured alcohol per brake horsepower-hour.

A fair idea of the best economy obtained in tests on engines of 10 to 15 hp. will be gained from the following tabulated results:

Fuel	Compression Pressure	Fuel per b.hp.-hr.	
	Pounds per sq.in.	Pounds	Gallons
Gasoline	70	0.60	0.100
	90	0.58	0.097
Alcohol	70	0.96	0.140
	180	0.71	0.104
	200	0.68	0.099

When denatured alcohol is used in 10- to 15-hp. four-stroke-cycle engines having a compression pressure of approximately 180 lb. and the engines are operated at their maximum loads, explosion pressures reach 600 to 700 lb.

From the foregoing it will be seen that under the proper conditions of compression, etc., the alcohol engine is as efficient as the gasoline engine or perhaps more so. Therefore, one must look to other causes to account for its disuse. A little study will show that it is purely an economic question; the price of denatured alcohol still remains prohibitive as compared with gasoline and not until these prices are more nearly equalized will the alcohol engine attain commercial success.

❖

Research Work on Large Diesel Engines

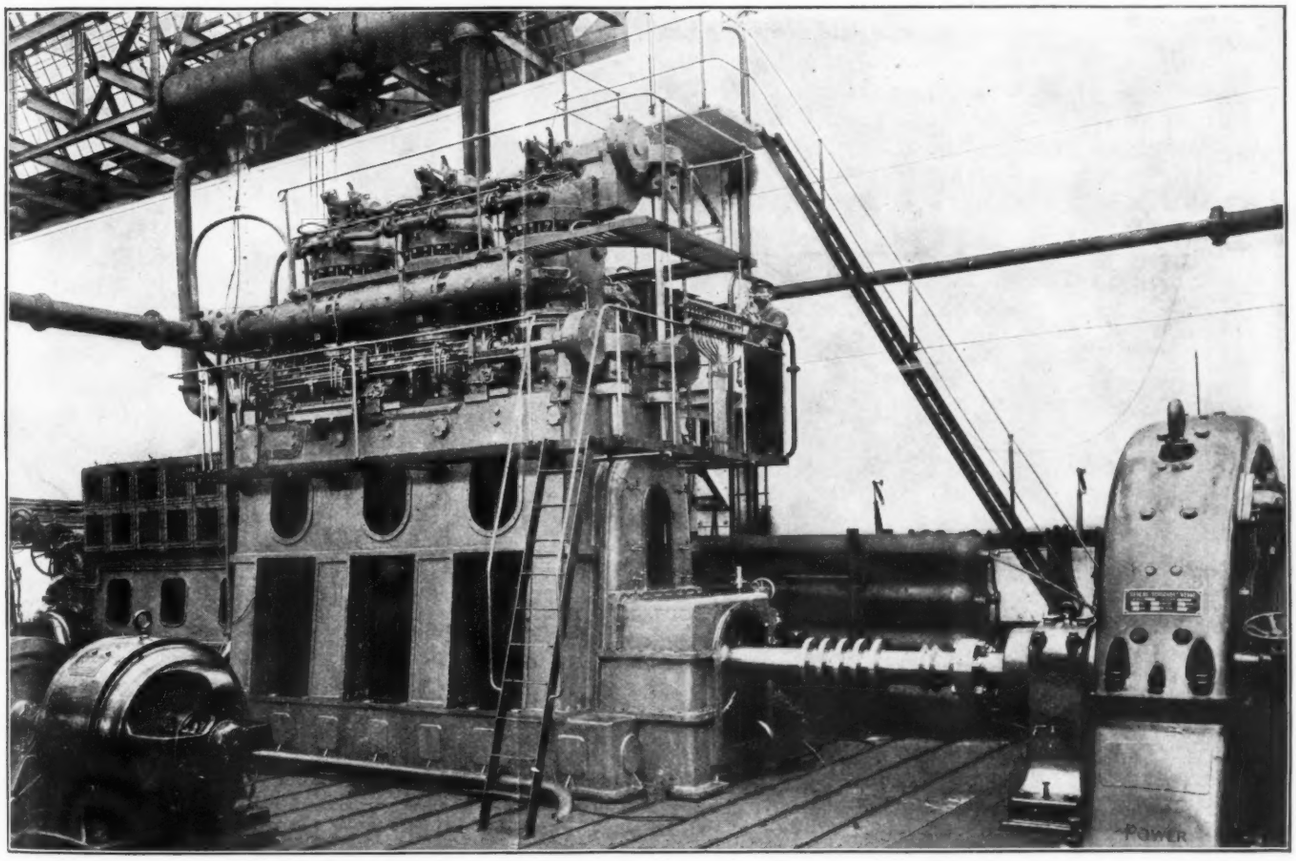
Among the firms which have contributed to the successful development of large Diesel engines in Europe, that of Blohm & Voss, shipbuilders, in Hamburg, rank second to none. Considering the great expenditure required for experiments of this character and the limited capital at the disposal of the individual concern, it is but natural that the tendency of manufacturers in Germany is to combine their financial forces in order to secure results in this complicated and expensive line of machine building. Accordingly, a research association was formed some time ago between the Maschinenbaugesellschaft Nürnberg and the aforesaid firm in Hamburg for the purpose of building large Diesel engines separately, testing details of construction, and exchanging the results.

The first engine built on this basis in Hamburg is herewith shown. It has three cylinders of 480-mm. bore and 650-mm. stroke (18.7x25.3 in.), developing 1000 b.hp. This engine has been on the testing floor of Blohm & Voss for 18 months and various experiments have been conducted with it, the purpose being to establish some fundamental deductions for the standard design of large double-acting two-stroke-cycle Diesel engines.

The research has been directed chiefly toward the evolution of reliable stuffing boxes, of suitable and safe covers for the lower cylinder sides, and of a simple governing gear. All these problems can now be considered as solved, and the firm is ready to guarantee the operating safety and durability of large double-acting Diesel engines. In other words, the difficulties attendant upon the double-acting principle have been practically overcome and it remains to study the difficulties associated with the heat conduction from the cylinder walls.

A new combination consisting of two three-cylinder units having an aggregate capacity of 2400 hp., and another of two single-acting, two-stroke-cycle, four-cylinder units with an aggregate output of 4000 hp., will be ready for testing early this year.

The new engines have an open frame and the scavenging pumps which, in the first experimental engine, were arranged on the prolongation of the shaft, are at the side, actuated by balance levers. The policy of Blohm & Voss is to build two-stroke-cycle engines up to 3000 hp., single-acting, and above this double-acting. This is because the complications involved in the double-acting engine are not welcomed by the operating attendants, who, in the smaller plants, do not often possess the required ability, and because up to sizes of 3000 hp. the economies to be realized as to space and weight are inconsiderable.



Large Double-acting Diesel Engine on Testing Floor of Blohm & Voss

HEATING AND VENTILATION

Graphical Solution of Heating Problems

In *The Wisconsin Engineer*, Prof. H. J. Thorkelson presented a useful chart for determining areas and cubical contents and an ingenious circular slide rule for calculating radiating surface. Both had been constructed by former students of the University of Wisconsin.

In meeting problems of heating and ventilation of the recent university buildings, the general plan followed was to provide direct radiation in the rooms to supply the heat necessary for the usual radiation and convection losses, and to install such additional indirect heating surface as required to heat the fresh air used for ventilation to room temperature. The direct radiation surface required for rooms was computed by deriving a formula based on the following heat losses per degree difference of temperature per hour per unit used: Radiation, glass, 1 B.t.u. per sq.ft.; wall, 0.25 B.t.u. per sq.ft.; convection 0.04 B.t.u. per cu.ft.

As outdoor temperatures of —20 deg. F. are frequent, it was necessary to base calculations on a 90-deg. difference of temperature, giving an hourly heat loss of

$$90\ (G + 0.25\ W + 0.04\ C)$$

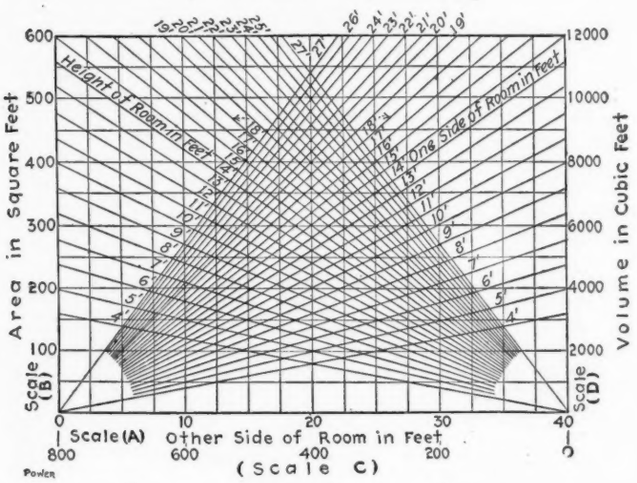


FIG. 1. AREA AND VOLUME CHART

where

G = Square feet of window opening;

W = Square feet of net exposed wall surface;

C = Cubical contents of the room.

With a heat transmission of 300 B.t.u. per sq.ft. of radiator surface per hour by a steam radiator, the above formula would indicate a radiating surface of

$$\frac{90}{300}\ (G + 0.25\ W + 0.04\ C) =$$
$$0.3\ (G + 0.25\ W + 0.04\ C)$$

and this was the formula used to determine the square feet of radiating surface.

To expedite calculations of this kind the chart shown in Fig. 1 will be found convenient. Areas are found by using the inclined lines from the lower left-hand corner and scale A for the two dimensions with the product shown on scale B.

If volumes are desired, the area is found as indicated on scale B and this result is transferred to scale C and followed in a vertical line to the dimensions of height shown on the lines radiating from the lower right-hand

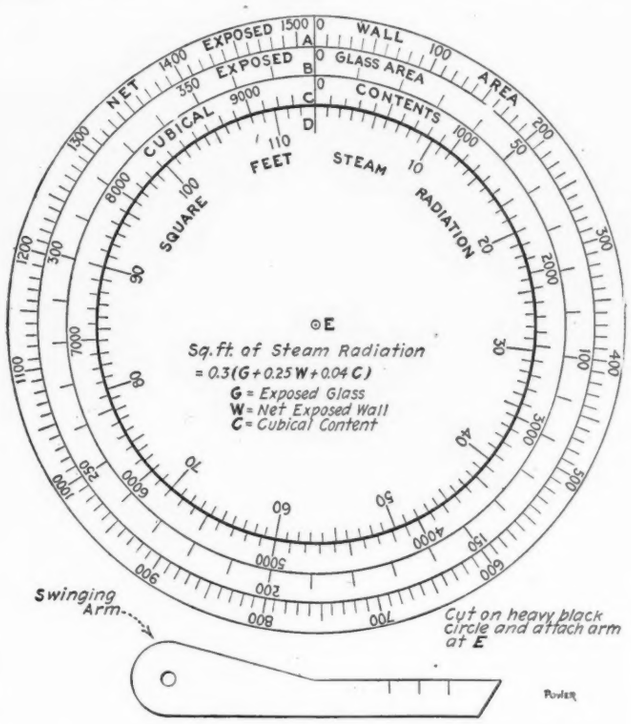


FIG. 2. CIRCULAR SLIDE RULE FOR DETERMINING RADIATION

corner; the volume will be shown in scale D. This enables easy calculations of G, W and C.

For simple calculations of the required radiating surface from the formula given the slide rule shown in Fig. 2 may be used.

Scales A, B and C are cut out in one piece, forming the movable scale of the slide rule, and D the fixed scale. A swinging arm is fastened to the center of the rule, and in starting both scales are set at O. The swinging arm is then moved on Scale B to the figure indicating G of the formula, and held there. The movable scale is then revolved until its zero coincides with the swinging arm. This arm is then moved on scale A to the figure representing W of the formula and held there.

The movable scale is then revolved until its zero coincides with the swinging arm. This arm is then moved on scale C to the figure representing C of the formula. Scale D will then show the square feet of steam radiation required.

If a gravity hot water system is used this result should be multiplied by 1.5 to obtain the required square feet of hot water radiation. If forced circulation is used this ratio may be reduced.

A New Arrangement of Heating Boilers

By Dr. Alfred Gradenwitz

Extensive heating plants supplied from a central boiler set have become more and more general of late years. Heating boilers had, accordingly, to be given ever larger dimensions, thus taking up more room and becoming more exacting as far as their superintendence is concerned.

Messrs. Gebrüder Sultzer's new large size boiler, which is shown in Figs. 1 and 2, and, like smaller heating boilers, is made up of several cast-iron units, is a decided advance in this connection. This boiler allows of convenient operation up to the following maximum dimensions: width, 5.9 ft.; height (including platform), 5.9 ft.; length 6.9 ft.

The heating area of a hot-water boiler of this size, by computation is 403.65 sq.ft., the grate surface 10.44 sq.ft. and the output under normal working conditions 1,270,000 B.t.u. per hr. The smallest size of this type of boiler is 3 ft. 3 in. in length and under normal working conditions it yields 555,550 B.t.u. per hr.

Low-pressure steam boilers apart from the fittings, have the same outward appearance, their top part serving as the steam compartment. On account of the low water level, the heating area in contact with water is, of course, somewhat smaller than the heating area of hot-water boilers of the same external dimensions. This would be 363.8 sq.ft. in the largest size boilers, the output being 1,143,000 B.t.u. at normal loads. The smallest size boiler of this type has a heating area of 157 sq.ft., the normal output being 778,000 B.t.u. per hr.

Fig. 3 illustrates the efficiency of the boiler at various loads, its coal consumption, flue-gas temperatures and the intensity of draft in the flue. These are the results of careful tests made on a hot-water boiler of 294.9 sq.ft. heating area, by the Swiss Association of Steam Boiler Owners. It may be noticed that the maximum efficiency has been found to be upwards of 86 per cent. while the average flue-gas temperature even at forced loads remained below 390 deg. F. These results have been exceeded on boiler plants in permanent operation with the government authorities of several states.

Fig. 1. Front View of Boiler

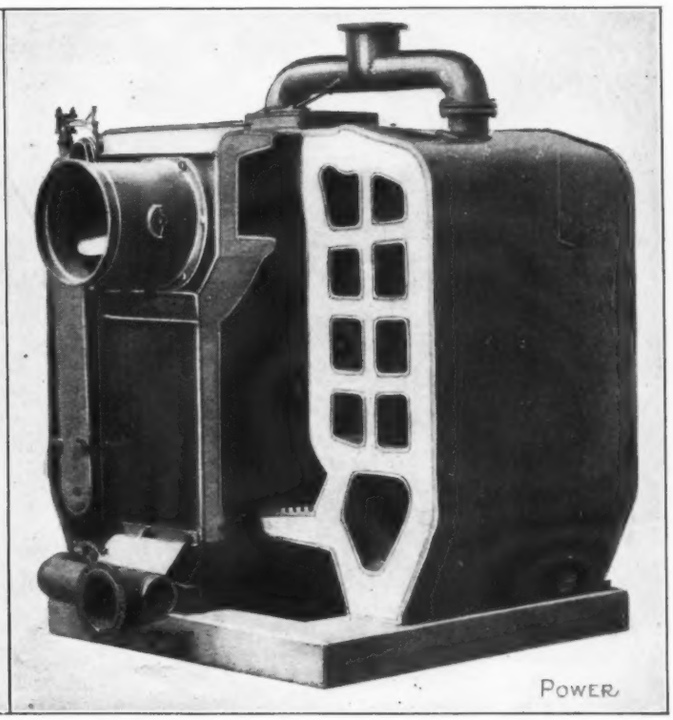


Fig. 2. Rear View of Boiler

If the heat consumption of a heating plant becomes so considerable that a single boiler is no longer sufficient, two or more boilers are combined. To reduce the space requirements to a minimum, the boilers are installed in batteries, being covered by common plates as represented in Fig. 4, which is a photograph of a low-pressure steam boiler plant recently installed at Schaffhausen, Switzerland. It comprises six furnaces of which any number can be operated at a time. The ground area covered by the boilers is 35.4x6.2 ft. = 220.7 sq.ft., the height from

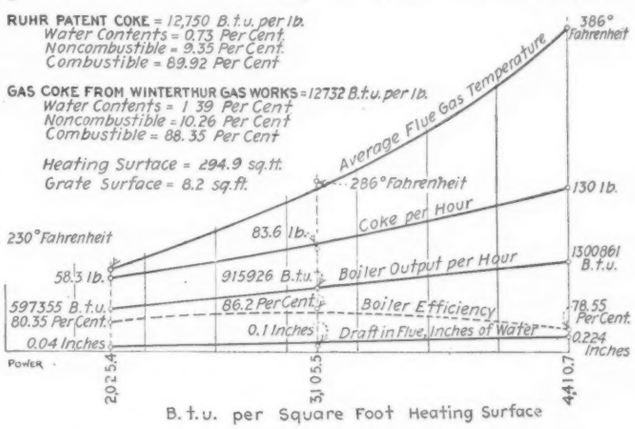


Fig. 3. Curves Plotted from Test Data

the floor to the platform being 7.87 ft. The total heating area in contact with water is 1976.3 sq.ft. and the drying surface in contact with steam 219.6 sq.ft.

The normal output of this set of steam boilers proves to be 6,214,000 B.t.u. per hr. As, however, further units are to be added, the total output after the ultimate completion of the boiler plant will amount to 15,872,000 B.t.u. The total coke-filling space for the time being, is 205.5 cu.ft., so that the boiler can run, without replenishing for about ten hours.

In these boilers the fuel may be readily inserted through an upper hopper on the platform and distributed by means of the door in the front wall. Sheet metal chutes, through which the coke slides down automatically from an elevated bunker, may be provided and the fuel may be conveyed from the store directly above the hoppers in trucks traveling on rails suspended below the roof. The flues run horizontally and after opening the front and rear doors, they can be cleaned without interfering with the service.

In Fig. 4 may be seen the gage glasses near the upper ends of the flue doors, as well as a vertical mercury gage for each boiler. At the bottom is the ashpit drop door.

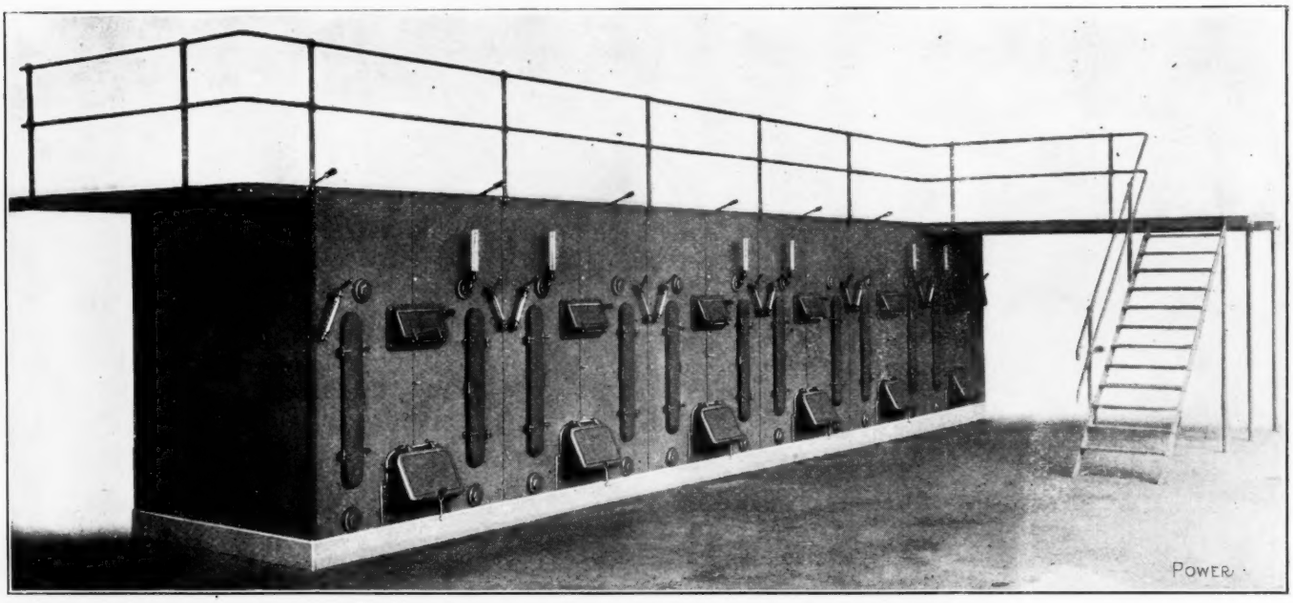


FIG. 4. A BATTERY OF SIX BOILERS

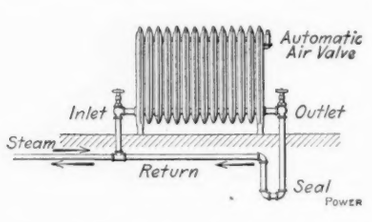


FIG. 1. TWO-PIPE RADIATOR ON SINGLE-PIPE SYSTEM

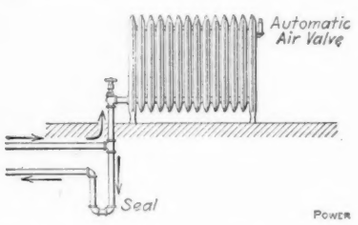


FIG. 2. SINGLE-PIPE RADIATOR ON TWO-PIPE SYSTEM

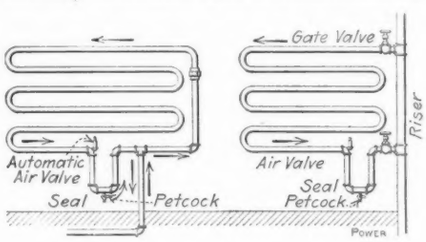


FIG. 3. COIL CONNECTIONS IN SINGLE-PIPE SYSTEM

Radiator and Coil Connecting

BY W. T. MEINZER

Engineers are often furnished with a nondescript lot of radiators and told to go ahead and heat up a building or add to an existing installation. They have to exercise their ingenuity to make a two-pipe radiator work quietly on a single-pipe system, or *vice versa,* but it can be done as Figs. 1 and 2 will show.

Fig. 3 shows methods of connecting a pipe coil on a single-pipe system. If the coil is long and the difference of pressure between the inlet and outlet is considerable, the discharge leg of the seal should be made the shorter to get the benefit of the head on the other leg.

When it is necessary to put a pocket in the steam-supply pipe to get to a coil on the ceiling, it may be drained into the return as shown in Fig. 4. If there is any doubt about the necessity of a seal in a return or drip pipe, be on the safe side and put one in. One unsealed connection to a line is generally allowable and is sometimes advisable. Each installation has its own problems and laying out the piping on paper first will greatly simplify the work. The obstacles will be anticipated, so that the installation work will be straightforward and there will be no occasion to reconstruct or modify any part of the system.

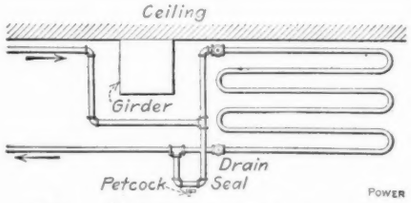


FIG. 1. DRAINING A POCKET INTO THE RETURN

EDITORIALS

Review of the Year 1912

As a whole the year 1912 was marked by little that was sensational in the power field, but it was a year of steady growth in nearly all lines. The best thought has been put to the development to the point of greater commercial usefulness of nearly all standard parts in the equipment of the power plant. Very many smaller improvements, far too numerous to mention within the scope of a review such as this, have been made, but in the following it will be attempted to enumerate only the most important events of the year.

Ever increasing attention is being given to the obtaining of higher efficiency in the making of the steam. To this end greater interest is being shown in flue-gas analysis and combustion recorders that firing may be improved. More opportunity to increase over-all efficiency is open in this direction than any other. In the last year considerable space has been given to the subject in these pages, and it is felt that the knowledge of this hitherto somewhat ill-understood phase of steam-plant operation is growing.

Applications of superheated steam are extending. The advantages realized from its use in steam turbines and locomotives, have led to new efforts to use it upon the part of those designing reciprocating engines, and notable steps have been taken to overcome the difficulties that were involved.

The necessity of the use of separators is being recognized, for although superheated steam is normally dry, local condensation may occur and can exist even in a surrounding of superheated steam. The elimination of moisture is especially important where the steam is used in turbines to reduce blade erosion. With the extending use of superheated steam, certain set principles of practice are being established. For example, what may be called moderate superheat is being generally settled upon, that is, of from 100 to 150 deg.

Exhaust-steam turbines continue to gain in recognition of their merits. Reciprocating engines in combination with turbines to use their steam through the lower ranges of expansion are the universally accepted means of obtaining the highest steam economy. Many more plants have been added to the number now containing these combination installations and by such arrangements many plants have been enabled to obtain necessary increased capacity without an extension of housing area.

A controversy was initiated by the results of Duchesne's investigation on superheat, when they were given publicity; thus far his findings seem to be questioned by more than give them credence. Briefly his conclusions were that determinations upon superheat in which mercurial thermometers were used were inaccurate; he determined the variation of the specific heat of superheated steam and showed that as the pressure increases all its properties become independent of the pressure and vary only as a function of the temperature. It remains for the authorities to establish the acceptability of Duchesne's results or the older ones.

The study of steam-engine performance received an important aid in the advent of the Clayton method of analyzing indicator diagrams. At the spring meeting of the American Society of Mechanical Engineers, the inventor, J. Paul Clayton, presented a paper indicating that there exists a relation more or less definite between the quality of the steam at cutoff and the exponent of the expansion curve. The exponent is easily determined by the pitch of the curve when reduced to a straight line by reference to logarithmic coördinates. The logarithmic diagram promised a means of determining the leakage into or out of the cylinder, and of the clearance, which promise does not seem to be fulfilled by its application to general work. The paper excited an unusual amount of discussion, which is still in progress.

Early in 1911 the Nordberg Manufacturing Co. built the first American uniflow steam engine and from the extensive tests made upon it developed the type which was put on the market last year. It differs from its German prototype, the Stumpf engine, in having Corliss instead of poppet valves, but obtains the same increased economy through largely reducing the loss due to initial condensation. This engine is remarkable for its great overload capacity and its flat steam-consumption curve and has particular advantages where the load is subject to wide fluctuations. The C. & G. Cooper Co. and the Mesta Machine Co. have also made engines of this type.

As to the progress of that most remarkable of power plants for its overall efficiency, the locomobile, nothing need be said in this review as a very complete article on this subject was given in the last issue.

The indications are that our government has returned to the reciprocating engine as the favored equipment for powering its battleships. Many consider that this decision has been too hastily reached and that the comparisons made between such turbine-driven vessels, as we already have, and those having reciprocating engines, although showing to the disadvantage of the former, should not have been taken so conclusively. The decision seems to have precluded allowance for improvements or modifications that may now be made in turbine installations on the strength of the experience which has been gained. Foreign builders of trans-Atlantic liners continue to equip them with turbines. Probably the two colliers, one to be equipped with reducing gears and the other with electric transmission between the turbine and propellers, will throw some new light on the problem of adjudicating the speed differences between the two ends of the system. Perhaps the most promising solution is to be looked for in a combination of reciprocating engines and turbines.

Among the several advances of moment as affecting the auxiliary equipment of steam-power plants may be mentioned improvement of chain and underfeed stokers to the point where their usefulness is considerably enhanced and their operation made more satisfactory; the application of

kinetic air pumps to surface condensers of large size and their much more general use, and the use of steel becoming the established practice for valves and fittings in steam lines carrying superheated steam.

A sorry muddle has been the only result so far of the attempt to establish a standard for pipe flanges and fittings. The American Society of Mechanical Engineers and the National Association of Master Steam and Hot Water Fitters collaborating proposed a set of specifications to which the manufacturers immediately took exception and brought out one of their own, so that there are now two standards, the United States and the Manufacturers. It is to be hoped that before another year draws to a close there may be a compromise and that one standard will be accepted by all.

Another new departure for American builders is the introduction of turbo-blowers and compressors. A line of these, recently announced by Henry R. Worthington, will be found referred to on other pages of this issue.

The contest between the isolated plant and the central station has continued and it would be hard to say which has gained the most ground. The most hopeful conclusion that can be drawn is that there is a growing disposition to yield the decision in any specific instance to the true engineering claims of either side. Unquestionably there are conditions where the one is decidedly preferable to the other and under such circumstances it is shortsighted to advocate the wrong service; it cannot but work to the later disadvantage of that class of service. Both have their fields and the rapidity of progress of each will be in proportion to the extent to which each confines itself to its legitimate field.

Regrettably, no more states have yet joined with Minnesota, Montana, Massachusetts and Ohio in adopting adequate boiler-inspection and engineers' examination laws. Several states are considering such legislation, and it is very probable that California will be the next to have its name put on the roll of honor, with more soon to follow.

Anent boiler safety, it is fitting to call attention to the new Jacobs-Schupert locomotive firebox. As distinguished from the ordinary radial-stay firebox, this one contains no stays, but, as described in the July 2, 1912, issue, is constructed of U-sections, between which are riveted stay sheets. A remarkable test of the two fireboxes fitted to standard locomotive boilers was made at Coatesville, Penn., last summer. The two were fired under full boiler pressure and the feed-water supply cut off. The radial-stay firebox boiler exploded when the water had fallen to 14½ in. below the crown sheet, but when the water was more than 25 in. below that point in the boiler equipped with the Jacobs-Schupert firebox, it was still intact and the test had to be discontinued when the water had fallen to the point where the evaporation would not keep up the draft. Evidently this year marked the discovery of an explosion-proof locomotive boiler.

Among new hydro-electric propositions is that under way near Pittsburgh. It is estimated that over 100,000 hp. can be developed when the installation is complete. The Keokuk, Iowa, hydro-electric development made considerable progress and during the summer the 7500-kw. generators were completed for the installation. Perhaps the most notable water-power work during the year was that done by the Great Western Power Co., in California, in extension of its present system. When the work now under way at Feather River is finished, this company will have added to its capacity about 600,000 hp., including the completed Big Bend plant, which alone contains four 15,000-hp. units.

Most of the advances in the electrical field during the past year have been in the transmission of power. Improved types of suspension insulators have made it possible to employ voltages heretofore regarded impracticable. Already there is a 140,000-volt transmission line in successful operation in Michigan, and a power development is under construction in California, which will employ 150,000 volts.

Alternating-current practice has not been alone, however, in this tendency toward the employment of higher voltages, for a trolley road has recently been put in service in Montana which operates on 2400-volt direct-current, and 1200-volt lines are becoming quite popular in the Middle West.

As regards generating equipment, the tendency toward larger units was evinced by the installation of 20,000-kw. vertical turbo-generators at the Waterside station of the New York Edison Co., and the Commonwealth Edison Co., of Chicago, has contracted for one of still larger size —a 30,000-kw. horizontal unit. Larger sizes have also spread to rotary converters, some 3000-kw. vertical machines having been installed during the past year. It might also be mentioned that these were the first of this class employing both the synchronous booster and the commutating-pole features.

In the gas-power field the greatest progress during the past year seems to have been in the oil engine. The exceptionally large Diesel engines, advocated so strongly a year or two ago, still appear to be in the experimental stage, but the small- and medium-sized Diesel engines have come to stay, and their use is becoming very general in Europe. A noteworthy event during the past year was the crossing of the Atlantic by the first Diesel liner.

The Junkers engine has also come into some prominence in Germany. While the use of the Diesel engine cannot be said to have spread very much in America, nevertheless, the expiration of the Diesel patents in the United States, during the past year, has been responsible for several engine builders putting out new oil engines, mostly in smaller sizes, and which may be classed as semi-Diesel in type.

Little advance appears to have been made in the large gas engine or gas producer during the past year, and the gas turbine is not as yet a commercial success. A unit expected to develop 1000 hp., built after the designs of Hans Holzwarth by Brown Boveri & Cie., at Mannheim, did not develop the expected power or efficiency, but indicates the direction of future effort.

The large increase in the use of gasoline engines, mostly for automobiles and the ever increasing use of petroleum byproducts, has created such a demand upon the oil market as to practically double the price of fuel oil in this country during the past year, which fact naturally has a tendency to impede the progress of the oil engine.

An event of the year, marking an important step in the advance of the Humphrey gas pump, was the decision, on the part of the Metropolitan Water Board, of London, to install five of these pumps. Four will be of 40,000,000 gal. per day capacity, and the fifth of half that amount. Some even larger units have been designed for the Egyptian Government, one being a pump capable of delivering 100,000,000 gal. per day, with a lift of 19 ft.

These are contemplated for the pumping station at Mex, in Egypt, for extensive irrigation work.

The refrigerating field has been greatly hampered by the difference in various tabulations given by different authorities as to the properties of working fluids used in refrigerating processes. During the year an appropriation was secured from Congress to enable the Bureau of Standards to standardize refrigerating data, and in the past month some noteworthy papers on the properties of ammonia were presented and should result in the adoption of working tables, which may be accepted with some degree of confidence as approximately accurate. There has also been a movement toward standardizing ammonia fittings. Making can ice from raw water is no longer impractical. A number of successful installations were made in 1912, and all indications point toward a rapid advance. From preparations now under way, the Third International Congress, to be held next September in Chicago, should prove a decided success.

One of the new instruments that have become available to the engineer in studying the performance of the equipment under this charge is the Vibragraph. With it, the intensity of vibration, on or near a machine, may be measured, indicating when it is of a serious nature and should be reduced. Modifications of the foundation or the balancing of revolving elements of a machine may then be made and tests repeated until it is found that more desirable conditions are obtained. Somewhat akin is the Detectorphone, which is quite completely described as "a mechanical stethoscope," being an instrument for rendering more audible any noises in piping or running machinery, so that derangements or other wrong conditions may more readily be located.

While the Panama Canal may not seem to have any very direct connection with the power field, its construction has called forth some quite radical applications of power. Now that it is likely to be opened many months ahead of the scheduled time, it will very shortly command attention on account of the provisions in the way of plant that will be necessary for its operation.

A gratifying tendency is the greater disposition to safeguard the lives of operatives and the public in the operation of industrial establishments and service utilities. In fact the humanitarian element is receiving more nearly its just consideration throughout all lines. This is evident not alone in the more extended adoption of safety devices in connection with power generating and power utilizing equipment, but also in efforts to improve the comfort and welfare of those in or surrounding power stations and factories, as by the reduction of the smoke nuisance, improvement of lighting and ventilation, provision of rest rooms, reading rooms, emergency hospitals, and generally more agreeable environment.

Among the men of prominence in the field of power-plant engineering who have passed away during the year just closed were the following, named in the order of their demise: James McBrier, president of the Ball Engine Co.; Richard T. Crane, founder and head of the Crane Co.; John B. Webb, consulting engineer and former professor of mathematics and mechanics at Stevens Institute of Technology; Francis H. Stillman, president of the Watson-Stillman Co.; Louis Delauney-Belleville, celebrated French engineer and inventor and manufacturer of the Belleville boiler; Read Admiral George W. Melville, noted engineer and explorer, past president and honorary mmber of the American Society of Mechanical Engineers; Dr. Henry W. Spangler, professor of dynamical engineering, University of Pennsylvania; Antonio Pacinotti, professor of physics, University of Pisa (Italy), and inventor of the multi-segmental commutator, distributed winding and toothed armature; Benjamin Guggenheim, president of the International Steam Pump Co., one of those lost on the "Titanic"; Jacob E. Friend, president of the Nordberg Manufacturing Co.; Otto Jahn, chief engineer of the Vilter Manufacturing Co.; Wilbur E. Richardson, principally known for his work in connection with mechanical lubricators; Theodore Albert, president of the William Powell Co.; George R. Babbitt, prominent consulting engineer and engine designer; James J. Waters, well known marine engineer, for years secretary of the Marine Engineers' Benevolent Association; Vaughan Pendred, for many years editor of *The Engineer*, London; Reuben Wells, veteran railroad man and locomotive constructor; Clement A. Griscom, one of the founders and first president of the American Society of Naval Architects and Marine Engineers; George A. Kimball, chief engineer of the Boston Elevated Ry. Co.; Alfred P. Boller, formerly chief engineer of the Manhattan Elevated R.R. and consulting engineer of the Department of Public Parks of New York.

The Prudential Insurance Company's Plant

Few, if any, office-building plants have grown so rapidly and under such exacting circumstances as that of the Prudential Insurance Co., as stated in the description in this issue. The total horsepower in 1890 was approximately fifty, and the plant consisted of only two small boilers and an electric-generating set. In 1900, when four more large buildings were added, completing the group of five, a plant large enough to meet the requirements was installed.

The electrical system of this plant was of the two-wire, 120-volt direct-control type, and served the demands until 1909 when two more large buildings were added to the group. At this stage of development 120-volt service proved too expensive to continue in view of anticipated further growth and the work of remodeling the entire system into a three-wire, 240-volt remote-control system was begun. One can imagine the thoroughness of cooperation necessary among those engaged in the work to make the change without causing a single interruption of service and to also obtain economy in the use of material and equipment.

Problems of a like nature, but not so complex, were met in completing the various pipe-line connections when the new plant was "hooked up" to the old. This work was also accomplished without service interruptions.

Consulting engineers in particular can appreciate the painstaking care and close study of details required, and the time and skill needed to prepare drawings necessary to successfully carry out the work. Operating engineers will realize the problems that had to be met by the plant engineers during these many additions and alterations, as they not only had to keep the plant going under trying circumstances but had to act as an information bureau for the numerous contractors as well as suggest ways and means of doing the temporary and permanent work so that all chances for service interruptions would be obviated. All this, combined with a general supervision of the installation and the selection of equipment which preceded it, was indeed a big task.

READERS WITH SOMETHING TO SAY

Simple Test for Cylinder Oil

Within certain limits, all lubricating oils look alike. Bearings which can be examined from time to time and watched by means of a thermometer offer the easiest solution for testing lubricants. In the cylinder of an engine it is entirely different. The test naturally must consist of introducing the lubricant and, after the engine has run for a time, examining the cylinder walls. Insufficient lubrication or a lubricant poor in quality are revealed either by "groaning" of the valves or else finding, when examining the cylinder walls, that scoring has begun.

With the view of adopting some simple and comparative means for testing cylinder oils, I have tried the following: From a piece of blotting paper, pieces 3 in. square were cut. Samples from the several cylinder oils to be tested were put in bottles (I use 4-oz. size) and these put into a room where all of them will reach the same temperature of about 70 to 80 deg. This requires 20 min. to half an hour. Three drops of oil of each kind were then put on the center of each piece of blotting paper. Each of these blotting-paper pieces was then put for a quarter of an hour on top of the engine where the metal was flat and at a temperature of approximately 210 deg. After remaining for 15 min., the piece was set aside.

The photograph shows eight samples that had been submitted for consideration. This picture shows more clearly than any descriptive matter the suitability or rather unsuitability of some of these oils for cylinder lubrication. Practically nothing was left of samples Nos. 7 and 8. The same might be said of No. 3. No. 4 was very doubtful and evidently contained a heavy body mixed with some lighter oil. Nos. 2 and 5 were samples from a high-grade, well known concern and these can be and were used as a basis of comparison. No. 1 was selected on account of the advantage in price and turned out to be as excellent in its work in the particular engine considered, as No. 2, which was tried under the same conditions.

I might add that when the samples were submitted the salesmen furnished the usual information regarding gravity, flash point and viscosity tests. These were all very much alike for the different samples. It is a fact that several oil makers—one in particular—have a lubricating oil and also an oil unsuited for lubrication, both of which have identical gravity, flash point and viscosity figures. This is mentioned as showing that this information is of little practical value in comparing the quality of several oils.

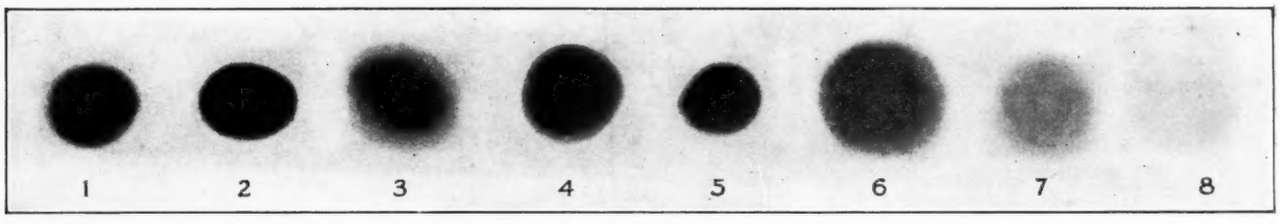
C. E. Fairbanks.

Providence, R. I.

[If the oil samples contained coloring substances it would seem that this test would not indicate the true nature of the oil.—Editor.]

Thawing Frozen Water Pipes by Electricity

Last winter I was employed by an electric light and power company in eastern Pennsylvania and as the weather was unusually severe, a number of water mains and service pipes throughout the city were frozen. The employees of the water company in thawing the pipes at first would dig open the pipe and thaw it with fire; this was slow and unsuccessful as they could make but a few openings in a day. About this time I suggested that they try electricity, which resulted in a total of twenty-six openings in three days. The following is a brief outline of how it was done:



Oil Samples after Being Subjected to Test Temperature

A 15-kw. transformer was mounted on the back of a one-horse wagon, and an ordinary wooden wash tub filled with salt water was set in the front end; then with the necessary wire and assistance, all was ready for action. The wagon was hauled to where the main was frozen and the primary terminals of the transformer were connected to the 2200-volt city primary lines through fused cutouts. One terminal of the secondary circuit of the transformer was then connected to a fire hydrant and the other to a metal plate of about 10x10 in. Another wire was connected to another fire hydrant, the frozen part of the pipe being between the two hydrants, and also to a similar metal plate to the one used for the second secondary terminal. The current was turned on and the plates immersed in the salt water near the sides of the tub and slowly moved toward the center until they were about an inch apart. The plates were held in this position until the water began to flow through the pipe. After the water first began to flow the current was turned off and the water completed the work. The time taken was never more than one hour in the case of a 10-in. pipe. After this work was completed the connections were broken and the wagon was moved on to the next "freeze."

The wire used should be about No. 10 for the primary

extensions and taps while No. 2 or 4 should be used for the secondary taps. Care should be taken not to fuse the transformer beyond its capacity, as serious injury would result.

Where service pipes are frozen, the secondary terminals should be connected to pipes in adjacent dwellings or stores. Frozen pipes about the power plant or those in factory yards can be readily thawed out in the manner described.

EDWARD C. WILSON.

Raleigh, N. C.

Correcting Turbine Governor Trouble

After starting a new 5000-kw. turbine it was found that it raced badly; in fact, there was a variation of 6 per cent. below and 4 per cent. above the normal speed of 1800 r.p.m. The erector for the turbine builders examined the governor valve, overload valve and tried out several types of balanced relay valves, but was unable to reduce either the vibration of the governor levers or obtain good regulation.

The turbine builders then sent their governor expert to inspect the control mechanisms. He tried two cushioning springs and a new type of piston in the dashpot, and while these devices gave closer regulation and more stability to the governor levers, they did not altogether overcome the vibration. He then shut down the machine to dismantle and thoroughly examine the governing mechanism. One of the governor gears was found to be cut out of true with the bore. The builders furnished a new gear immediately, which was installed and corrected all the trouble.

D. J. O'BRIEN.

Birmingham, Ala.

Flameless Combustion

Under the title of "Flameless and Surface Combustion," Professor Bone has been much heralded as the inventor of something remarkable in the combustion line. The leading engineering papers and newspapers and some of the technical societies have given publicity to his schemes, which are disposed to mislead many who are not especially familiar with such problems. Therefore, I would call attention briefly to certain features which perhaps have been overlooked:

Flameless combustion, as the term is used, is a misnomer. All combustion is flameless. The "combustion" which is accompanied by flames is not combustion at all; it is simply a state which is attempting to arrive at a condition of combustion. The luminosity of a flame is due to the incandescence of free carbon, which has been broken down by heat from a hydro-carbon gas and which maintains its luminous condition for that very short, but indefinite interval preceding its union with oxygen, in the formation of CO_2, or its cooling and its escape as a particle of black soot in smoke. This is illustrated by the burning of anthracite coal, containing a very small amount of hydro-carbons, which burn with very little flame, or by hydrogen, which burns with no flame at all. If Professor Bone had said immediate combustion, it would have been technically accurate.

So far as the feature of surface combustion is concerned, the only significance is that he obtains a good mixture between gas and air by the use of such material as firebrick, etc., which has no influence, whatever, in the way of promoting "surface" combustion, but does perform a service as a mixing device. So really, the whole process as described may be summarized by saying that it is immediate combustion of gas brought about by the agency of a mixing device, and this is all there is to it. Thus, it is apparent that there is nothing new in this much heralded method.

The application of gas to combustion in the case of a steam boiler as illustrated by Professor Bone is impracticable for reasons of cost with respect to forcing the gas through the boiler if for no other reason. The high rate of evaporation may be more easily obtained with a coal fire under ordinary conditions if a high condition of combustion is employed. In fact, the only example of the application of combustion, which in my opinion has any value, is the one in which a crucible is heated by gas which is mixed with air between the pieces of a refractory material such as firebrick surrounding the crucible.

Chicago, Ill.

A. BEMENT.

Turbo-Condenser Problem for Discussion

Will interested readers of POWER tell me what was wrong with our Parsons type steam turbine. It had been set up and run about ten weeks, when suddenly the vacuum fell to 15 in. At this vacuum it would not carry its load of a thousand kilowatts.

The dry-vacuum pump is of the jet type, but would not work. Repairmen worked on it quite a while and finally gave it up. The pipes were all overhauled and cleaned and the pump still refused to work. Then the experts from the turbine company came and spent much time investigating, but with no good results. These men had packed their grips and were ready to start away when they tried the turbine again; it started and worked as it should. It has been running well since except when a mud turtle stopped the intake pipe to the condenser.

It takes about 29.5 in. of vacuum, when the air pressure is 30 in. to carry the thousand kilowatts on the machine.

STANLEY C. ALLEN.

Lansing, Mich.

Friction Loss in Wrought Iron Pipe

In reply to Mr. Kent's criticism on page 868 of the Dec. 10 issue, on my chart for determining the friction head due to the flow of water in pipes, I call attention to the fact that due to a typographical error the ordinate 0.15 was printed 0.1 and the ordinate 0.1 was printed 0. As a matter of fact, when using logarithmic paper in plotting curves it is impossible to reach zero, as may be easily seen by examining a sheet of logarithmic paper. If the top line is taken as 10, then the bottom line is 1. If another sheet is added below, the lowest line is 0.1, on the next sheet 0.01, on the third 0.001, and so on. Substituting the figures given above will correct the discrepancy in the chart.

W. L. DURAND.

Brooklyn, N. Y.

QUESTIONS BEFORE THE HOUSE

Simplifying Indicator Diagram Analysis

Having been interested in the articles in POWER relating to indicator-card analysis, I would offer the following as a more convenient way of finding the value of n in the formula

$$pv^n = c$$

where the engineer is reasonably certain of the correctness of the expansion line.

In the formula, n equals the ratio of the specific heat at constant pressure to the specific heat at constant volume

$$n = \frac{log.\ p_2 - log.\ p_1}{log.\ v_1 - log.\ v_2}$$

where p_1 and p_2, v_1 and v_2 are two different pressures and their corresponding volumes, taken directly from the expansion line of the diagram under consideration.

The proof of this is a simple mathematical one, involving the subtraction of the two logarithmic equations of

$$pv^n = c$$

By using this value of n the weight of steam in the cylinder at cutoff can be found as described in Prof. Clayton's article in POWER for June 18, 1912.

But it is also necessary to know the volume of steam at the beginning of compression, to calculate the steam consumption of the engine. This may be found as follows: By taking any pressure p_3 and its corresponding volume v_3 from the compression line of the diagram, the constant (c) for this line is readily determined, n for the compression line being derived in the same way as for the expansion line. For log. $c = log.\ p_3 + n\ log.\ v_3$. c being known, we may now take a value of p equal to the exhaust pressure of the engine, say p_4. Then the volume of the steam at this pressure, that is, the volume of the steam at the beginning of compression, is found from the formula

$$Log.\ v_4 = \frac{log.\ c - log.\ p_4}{n}$$

c, p_4 and n being known.

The use of this method obviates the necessity of plotting the diagram to logarithmic coördinates every time the engineer desires to find a value of n wherefrom to calculate the steam consumption of his engine.

LLOYD W. TAYLOR.

Grinnell, Iowa.

❖

Steam Gage Problem

On page 799 of the Nov. 26 issue, Mr. Pollard offers a solution of a steam-gage problem. I do not approve of his manner of procedure in correcting defective gages.

In the first place when the gage showed signs of working badly it should have been taken down and tested; and if found wrong and the trouble located in the gears it should have been sent to its manufacturer for repairs, who no doubt would have replaced the worn parts with new ones instead of using the old ones. Then the gage would have been calibrated and returned in first-class condition.

The mechanism of a steam gage is very delicate and the parts are made to work with one another with the least possible lost motion; and when these parts wear enough to form a shoulder, so large as to retard the action of the gage, and are then dressed down with a file, the reading is bound to be inaccurate. And this inaccuracy is unlikely to be uniform throughout the range of registering.

Steam gages are the engineers' guide and are no instruments to be tampered with or experimented on by unskilled hands. Nor is the boiler inspector fitted for this work.

The maximum repair cost to a defective gage, or even the price of a new one, is cheap, when it is known that the instrument can be depended on to register correctly.

GEORGE B. LONGSTREET.

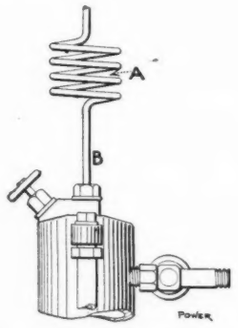
Somerville, Mass.

❖

Repairs to Lubricator Condenser

Under the above heading in the Oct. 29 issue, Alford H. Smith of Rogers, Ark., describes how he repaired a broken lubricator. The condenser, that pear-shaped bulb affair we usually see attached to hydrostatic lubricators, was broken, so he replaced it with a straight piece of pipe, and the lubricator gave no further trouble.

I have often wondered if these attachments are necessary on lubricators, and have removed some of them in a somewhat similar manner to that employed by Mr. Smith, with satisfactory results.



LUBRICATOR WITH COIL OF PIPE AS CONDENSER

The condensation in 8 or 10 in. of ¼-in. pipe should be sufficient to operate the lubricator under ordinary conditions. I suppose that the object of this globular condenser is to store a comparatively large quantity of water for use in emergencies, but it has its disadvantages. If the condenser ever gets hot, the lubricator will refuse to start for five or ten minutes, i.e. until two or three ounces of water has accumulated in the condenser.

An engineer not well acquainted with this style of

lubricator is apt to lose patience, and to "monkey" with the valves in his endeavor to locate the trouble. Perhaps the answer to this would be to keep the condenser cool, but we all know that there are occasions when they will become heated. If the lubricator is allowed to become empty of oil the condenser will get hot, as it will also when sometimes steam is allowed to blow through the lubricator to clear it of sediment. When filling the lubricator, care should be taken to fill it to the top. If, for any reason, the oil supply at hand is insufficient to completely fill the reservoir, the balance should be made up with water, otherwise the lubricator will get very hot and refuse to start feeding for quite a while.

The most satisfactory condenser I have used is shown in the sketch. The coil *A* is made of ⅛-in. iron pipe (brass might be better). It is formed by heating the pipe to a cherry red, and winding a few turns of it around a mandrel, say a piece of 1½-in. pipe. In operation the short length of pipe *B* will fill with condensation in a few seconds, so that there is never any delay in getting the lubricator to start feeding.

B. Copping.

Kankakee, Ill.

Silica in Boiler Water

W. A. Lee brings up a point in the Nov. 19 issue regarding the deleterious effect of silica in the boiler-feed water which is frequently overlooked. In fact, in many of the analyses made to determine the proper chemical treatment of a feed water, the silica is not reported. It must not be inferred, however, that it does no harm. The reason that attention is not more often paid to it is because none of the ordinary softening systems remove it to an appreciable extent. This is not intended as a criticism of softening systems, for it must be said that if the lime and magnesia are properly removed it will not be necessary to get rid of the silica.

It is in untreated water that silica causes trouble. I have analyzed many samples of water and found that the average silica content is 0.95 grain per U. S. gallon. This figure is based on the results of 100 analyses of water taken from all over the United States and Canada. The figures run all the way from an indeterminate quantity to 6.25 grains per gallon which was found in a deep well water in St. Louis. Where the amount is less than one grain per gallon it is improbable that the scale is much affected. When the silica content becomes much greater, however, the scale is apt to be much harder than it would be otherwise.

Just how the silica occurs in water is not known exactly. Silica itself is almost insoluble and it is believed to be present ordinarily in the colloidal form, which is in the region between a true solution and matter in suspension. It will not ordinarily form scale itself but will combine with lime and magnesia scale to form a good imitation of stone. When the other scale-forming impurities are removed any ordinary amount of silica will cause no trouble whatever, particularly if the feed water is very slightly alkaline.

As Mr. Lee says the boiler is no place for chemical reactions to take place, for dense masses of soft scale are precipitated which are likely to collect on the lower sheets and bake and burn out the plates. With much silica present, this is also likely to unite with the soft sludge and make hard scale. Furthermore, the large amount of suspended, precipitated matter floating around in the boiler promotes foaming.

The proper method is to precipitate the lime and magnesia salts outside of the boiler with lime and soda or heat and soda, except in special cases when other chemicals may be preferred. By settling and filtering there is then obtained a clear, soft water, well adapted for boiler feed, or other purposes. When engineers begin to realize this there will be fewer leaky or bagging tubes, hard scale will not be known, corrosion will be done away with, the tendency to foam will be decreased, and all concerned will be satisfied that the investment necessary was well justified.

Edward H. Robie.

Philadelphia, Penn.

How the Valve Deck Was Cracked

Referring to the above communication by John McGinness in the Nov. 26 issue, I wish to say that I had practically the same experience with a duplex fire pump. At the time I decided that it was due to unequal shrinkage of the metal during the cooling of the casting and that later, pressure opened up these shrinkage cracks.

This is evidently what has happened to Mr. McGinness' pump, and the remedy would be to rib the water end longitudinally on the inside and be sure that the cylinder when being cast is made of hard close-grained charcoal iron, and after being cast is left in the sand long enough to cool off thoroughly.

The only other explanation I can give without seeing the actual break is that the valve seats along the lines of fracture were forced in under pretty good pressure and put a strain on the metal which resulted in a crack.

A. Rauch.

Swissvale, Penn.

Painting Boiler Shells to Prevent Pitting

Reading the article in Power under the heading "Zinc Paint as Corrosion Preventive," in the Nov 5 issue, brings to mind troubles I had several years ago with corrosion in 26 water-tube boilers. I tried everything I ever heard of without good results and at last concluded that I must keep the water from coming in contact with the shell plates to overcome this corrosion, which was becoming serious.

I finally hit upon the following plan, which had the desired effect: First I cleaned the shell plates thoroughly with a scraper and a wire brush. Then I painted the plates with paint made of boiled linseed oil and portland cement. When this first coat dried, I put a second coat on composed of one part graphite and three parts cement.

Three years later when I left this plant this very thin scale formed from these coatings was still there and no more pitting had started nor had any of the old "pock marks" grown larger. The graphite added to the second coat keeps the scale from sticking to the paint and, despite the expansion and contraction of the metal, the paint strongly adheres to the plates.

C. H. Liebfield.

Kansas City, Mo.

INQUIRIES OF GENERAL INTEREST

Allowable Load on Stay-bolts

How many pounds per square inch working pressure would be resisted by 1¼-in. diameter stay-bolts 12 threads per inch pitched 6x6 in., the allowable load being 7000 lb. per sq.in. net cross-sectional area?

P. F.

A stay-bolt 1¼ in. in diameter with 12 threads per in. would have a diameter at the bottom of the thread of

$$1\tfrac{1}{4} - (\tfrac{1}{12} \times 1.732) = 1.1057 \text{ in.}$$

hence the net cross-sectional area at the bottom of the thread would be

$$1.1057 \times 1.1057 \times 0.7854 = 0.9602 \text{ sq.in.}$$

and the net allowable load would be $0.9602 \times 7000 = 6721.4$ lb.

The area of the stay-bolt at the bottom of the thread being 0.9602 sq.in., the net area supported by one stay-bolt would be

(6 in. × 6 in.) — 0.9602 sq.in. = 36 — 0.9602 = 35.0398 sq.in.

therefore, the allowable boiler pressure sustained by the stay-bolts would be

$$\frac{6721.4 \text{ lb.}}{35.0398 \text{ sq.in.}} = 191 \text{ lb. per sq.in.}$$

Setting D-slide Valve

How is an ordinary D-slide valve set to get equal lead and equal cutoff and how can the lead and cutoff be varied?

E. D.

The valve will have equal lead and equal cutoff if it has the same amount of lap on both ends when it is in the middle of its travel. To equalize the lap, first lay off the outside edges of the steam ports on the valve seats outside of the valve by pencil lines drawn square across the valve seat, and locate a point half-way between them. Next mark the extreme points of travel of each end of the valve and turn the wheel of the engine so the valve stands in the middle of its travel. The eccentric will then be at the middle of its throw and without moving the wheel the valve is then to be adjusted on the valve steam so it will have the same amount of lap over the steam port at each end of the valve. The valve will then be set for equal lead and equal point of cutoff. Having set the valve central, lead and cutoff can be made earlier by advancing the eccentric on the shaft or both can be made later by setting the eccentric backward on the shaft.

Harmless Fault of Alignment

In lining up a large horizontal engine it is found that the center line of the cylinder, when extended, is approximately ⅛ in. above the center of the shaft. What effect will such want of alignment have on the strains and general operation of the engine?

H. V.

The strains in the connecting-rod and friction of crosshead, crank and main bearings will be increased but not to any appreciable extent. In general operation this fault of alignment would have no perceptible effect.

Objections to Side Fire Door

What objections may there be to having the fire-door opening for a return-tubular boiler setting in one of the side walls in place of the front wall?

J. M.

The side-wall construction is weakened by such an opening and it should not be employed except possibly with a suspended type of setting. The leading objections in operation are that the radiation and reflection of the furnace heat from the opposite side wall result in considerable loss of heat through the fire-door opening. Unusual heating of the boiler room and inconvenient location of the firing door with respect to the grate and direction of the draft all tend to increase the difficulties of firing skillfully.

Operation of Ammonia Refrigerating System

In what part of a direct-expansion system does expansion of the ammonia take place, and what are the leading conditions for most economical operation of plants of this kind?

P. M.

Expansion of the ammonia takes place in the expansion coils, which are located in the space or room to be cooled. The lower the pressure and temperature in the condensing coils and the higher the pressure and temperature in the expansion coils (i.e., suction pressure), the more economical will be the working of the plant.

Relative Amount of Copper in Two-phase and Three-phase Systems

Why is the copper required for the transmission of a given power by a three-phase, three-wire system only three-quarters of that necessary with two-phase, four-wire systems, the voltage, distance and the line losses being the same in both cases?

H. K.

In the three-phase system let the voltage between wires be E_1, the current in each wire be I_1, and the resistance be r_1. In the two-phase system let these respective quantities be E_2, I_2 and r_2. For simplicity let the three-phase system be delta-connected and the load be nonconductive; then $E_1 = E_2$. The power in the three-phase system $= E_1 I_1 \sqrt{3}$ and in the two-phase system $2 E_2 I_2$. Then

$$E_1 I_1 \sqrt{3} = 2 E_2 I_2$$

whence

$$I_1 \sqrt{3} = 2 I_2$$

or

$$I_1 = \frac{2}{\sqrt{3}} I_2$$

The line losses in the three-phase system are $3 (I^2_1 r_1)$ and in the two-phase system

$$4 (I^2_2 r_2)$$

Therefore, by substituting and equating

$$3 (\tfrac{4}{3} I^2_2 r_1) = 4 (I^2_2 r_2)$$

whence $r_1 = r_2$.

This means that the wires are the same size but as there are three wires in the three-phase system and four in the two-phase system the former requires only three-quarters as much copper.

Most Economical Steam Pressure for Automatic Engine

What would be the relative coal consumption of an automatic engine running with 80 lb. of steam as compared with 40 lb. and the same load?

A. B.

The economy depends on the point of cutting off required in each case as determined by the amount of the load and the size of the engine cylinder.

Rating of Refrigerating Machines

What is the method of rating refrigerating machines?

T. B.

(1) Refrigerating capacity, and (2) ice-making capacity, both expressed in tons per day of 24 hours.

One ton of refrigerating capacity would mean that under assumed or stated conditions, as range of temperature, the machine would remove the number of heat units equivalent to that required to melt one ton of ice at 32 deg. F. into water at 32 deg. F. in 24 hr. In the United States 288,000 B.t.u. per 24 hr. per ton of refrigeration is the recognized figure, being made up of 144 B.t.u. per lb. of ice melted and a ton of 2000 lb. This gives 12,000 B.t.u. per ton per hour and 200 B.t.u. per ton per minute, the temperatures selected through which the machine is supposed to work being 90 deg. F. in the condenser and 0 deg. F. in the expansion coils.

Ice-making capacity is a measure of the actual weight of ice made by a machine (designed for ice making) in tons per 24 hr., assuming the normal conditions of summer weather. It is usually about one-half the refrigerating capacity.

Inside Lap

What is inside lap and what is the object of putting inside lap on a valve?

R. G.

Inside lap or exhaust lap is the amount the exhaust edges of a D-slide valve overlap the exhaust edges of the cylinder ports when the valve is in mid position. In adding sufficient steam lap to bring about good cutoff, the exhaust is apt to be released too early, and exhaust lap is provided to obviate such a defect.

Evidences of Leaky Piston

How would a leaky engine piston be shown on an indicator diagram?

E. J.

A leaky piston would cause the expansion line to fall too low; it would also show too high back pressure of the exhaust while the exhaust valves were open, and would prevent full compression of the exhaust after closure of the exhaust valves.

Lowest Safe Water Line in Horizontal Return-tubular Boilers

Where should the bottom try-cock be placed on a horizontal tubular boiler, in relation to the tubes?

W. R.

The lowest try-cock, the lowest visible part of a water gage-glass and the location for fusible plugs should not be less than 2 in. above the upper surface of the upper row of tubes.

Cause for Fracturing Wristplate Centerpin

What might cause the wristplate-centerpin of a 14x36-in. Corliss engine to break repeatedly? Fracture of the pin occurs in each instance close up to the shoulder.

S. R. B.

Fracture might result from the pin being turned with a sharp corner instead of a fillet at the shoulder; but repeated breaking of pins would seem to indicate that the wristplate becomes jammed by one or more of the valve rods dead-centering with the valve arms, as might happen if the valve-arm keyways have been improperly laid out on the valve stems, or the right-and-left connections between the valves and wristplate have been shortened too much.

ENGINEERS' STUDY COURSE

Cube Root

The cube of a number is the product of a number taken three times as a factor, thus

$$3 \times 3 \times 3 = 27$$

which is the cube of 3.

The cube root of a number is a number which taken three times as a factor will produce that number. In the above example we see that the cube root of 27 is 3.

As we just learned how to find the square root of a number, the process of finding the cube root will come easy. Let it be understood at the beginning that it is so seldom necessary to find the cube root of a number that nearly all who have learned how must refresh their memory each time they are required to do an example in cube root. We will explain the process of finding cube root by the long method, and learn how to find the cube root by the use of a table.

In square root we point off the number into periods of two places each, but in cube root a period consists of three figures. We begin to point off at units place; to the left of the decimal point for whole numbers and to the right for decimals; just as we did in our square-root lesson. As in square root so in cube root, the number of periods indicates the number of figures there will be in the root.

In our square-root lesson we learned that when a number was not a perfect square and we wanted to carry the root out to decimals we had to annex a period of two ciphers each for every decimal place added to the root. The same is true of cube root, except that a period of three ciphers is added for every added decimal place.

Example: What is the cube root of 79,507?

For convenience a table of cubes from 1 to 9 is given below.

$1^3 = 1$	$4^3 = 64$	$7^3 = 343$
$2^3 = 8$	$5^3 = 125$	$8^3 = 512$
$3^3 = 27$	$6^3 = 216$	$9^3 = 729$

```
   4                                  root
   4                      79 507 )43 ans.
1600 × 3 = 4800           64
                          15 507
     4                    15 507
     3
 120 × 3 = 360
             9
          5169
            23
       15,507
```

Pointing off, we have two periods, so we know there will be two figures in the root. Now we find the greatest number the cube of which does not exceed 79. This is obviously 4, and the cube of 4 is 64 which is put under the first period 79, and subtracted, giving a remainder of 15. Now bring down the next periol, getting a dividend of 15,507.

To get a new trial divisor we set down at the left the 4 in the root and square it, getting 16, to which we add two ciphers. We now multiply 1600 by 3 getting 4800 which is our new trial divisor and indicates a quotient of 3. The next step is to multiply the first figure of the root by the second figure which is 3, and add a cipher to the product. This gives us

$$4 \times 3 = 12$$

and the cipher added equals 120, which must be multiplied by 3, giving 360. (We used 3 as a multiplier of 1600 and 120, not because it is the second figure of the root, but because 3 is used as a constant at this point of the process in all cube root examples.)

Set this 360 under the 4800 then square the second figure of the root getting 9, which we set down under the 360. Now add the column of figures, which gives

$$4800 + 360 + 9 = 5169$$

which is the complete divisor and must be multiplied by the second figure of the root or 3. The product equals the dividend, leaving no remainder which shows that 79,507 is a perfect cube.

Let us take another example that will contain three figures in the root so as to show how the trial divisors are obtained when there are more than two figures in the root.

Example: Find the cube root of 669,921,875.

```
   8                                  root
   8                      669 921 875 ) 875 ans.
6400 × 3 = 19,200         512
                          157 921
     8                    146 503
     7                     11 418 875
 560 × 3 = 1,680           11 418 875
            49
        20,929
             7
       146,503
  87
  87
 609
 696
756,900 × 3 = 2,270,700
     87
      5
 4350 × 3 = 13,050
            25
     2,283,775
             5
    11,418,875
```

From what was learned in the previous example, the process in the above example is plain up until it is necessary to find a trial divisor for the third dividend which is 11,418,875. To get this trial divisor we combine the two figures of the root already obtained and square them,

$$87^2 = 7569,$$

and then we annex two ciphers and multiply by 3. This gives us

$$756{,}900 \times 3 = 2{,}270{,}700$$

which is our trial divisor. We find that it will go into

the dividend 5 times, so write 5 as the third figure of the root. Now combine the two first figures of the root and multiply by the third figure

$$87 \times 5 = 435$$

and annex a cipher to the product, giving 4350.

This is now multiplied by 3 which gives 13,050 and is set down under the 2,270,700. Next square the third figure of the root, getting 25 and set it down under the 13,050. Now add the column

$$\begin{array}{r} 2{,}270{,}700 \\ 13{,}050 \\ 25 \\ \hline 2{,}283{,}775 \end{array}$$

which is the complete divisor for the dividend 11,418,875. As the divisor is contained in the dividend 5 times without a remainder the number is a perfect cube.

To prove examples in cube root use the root three times as a factor. Thus to prove our first example,

$$43 \times 43 \times 43 = 79{,}507.$$

If at any time it is found that the product of the complete divisor by the trial figure of the root exceeds the dividend it will be necessary to correct the work to conform to the next lowest trial figure in the root. If ever the dividend is less than the trial divisor, place a cipher in the root, bring down another period, annex two ciphers to the trial divisor and proceed as before.

By this time we have learned that the process of finding the cube root of a number is very laborious and we can therefore, appreciate the value of a table that will tell at a glance just what is the cube and cube root of a number, and of course, which also gives the number when the root is known.

Nearly all engineers' hand- and pocketbooks contain tables giving the squares, square root, cubes and cube roots of numbers from 0.1 to 1000 and over. Kent's Mechanical Engineers' Pocketbook gives numbers from 0.1 to 1600. In this book the numbers from 0.1 to 10 increase by tenths, and all numbers from 10 to 1600 increase by 1.

Parts of this table are given below so the reader may more fully appreciate the value of such tables.

No.	Square	Cube	Sq.Root	Cube Root
.6	.36	.216	.7746	.8434
.65	.4225	.2746	.8062	.8662
.7	.49	.343	.8367	.8879
.75	.5625	.4219	.8660	.9086
.8	.64	.512	.8944	.9283
2	4.	8.	1.4142	1.2599
.1	4.41	9.261	1.449	1.281
.2	4.84	10.648	1.483	1.301
.3	5.29	12.167	1.517	1.320
.4	5.76	13.824	1.549	1.339
.5	6.25	15.625	1.581	1.357

No.	Square	Cube	Sq.Root	Cube Root
210	44100	9261000	14.4914	5.9439
211	44521	9393931	14.5258	5.9533
212	44944	9528128	14.5602	5.9627
213	45369	9663597	14.5945	5.9721
214	45796	9800344	14.6287	5.9814

The reader should occasionally do examples in cube root so that should he be called on to find the cube root of a number when a table was not available or when the cube root could not be found from a table he would not be "stuck."

Examples for Practice

1. What is the number of which 9,393,931 is the cube?

2. Find the cube roots of the following numbers: (a) 0.8; (b) 2.5; (c) 213.

3. What is the number of which 44 is the cube root?

4. The diameter of a sphere is found by dividing its cubical contents by 0.5236 and extracting the cube root of the quotient.

It is desired to make a cast-iron ball to weigh 364 lb. Cast iron weighs 0.26 lb. per cu.in. What would be the required diameter?

5. D. K. Clark gives as a rule to find the diameter of a shaft capable, within good working limits, of transmitting a given horsepower:

Multiply the horsepower by 285 for cast iron, by 190 for wrought iron and by 92 for steel; divide by the speed in turns per minute. The cube root of the quotient will be the diameter in inches.

According to this rule what would be the diameter of a steel shaft required to transmit 20 hp. at 200 r.p.m.?

Answers to Last Week's Problems

(1) (a) 3.285; (b) 18.06; (c) 0.028; (d) 3899.
(2) (a) 2.6458; (b) 3.60556.
(3) 42 ft.
(4) 85 in.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"FOREWORD"

It's plain to you upon its face
That Power's need for much more space
Has driven us to serve these "spills"
In capsule doses for your ills.
So when a joke's not over-ripe
We'll put it here in "six-point" type.

Our friends the marine engineers have fittingly chosen German Artillery Hall in which to hold their festivities during the Charleston convention. Let each doughty warrior gird himself for the fray, be served with abundant "ammunition," and be placed where the "shots" fall the thickest. Charleston this day expects every man to do his duty. The watchword will be Prosit!

Catherine Morris, of Pittsburgh, attired in men's clothes, worked in boiler and machine shops for three years before anybody discovered she was just Cathy. During this time she demonstrated she was some white hope by licking a shopmate in a fist fight, and she has a scar on her face to prove it. From all this, one is assured that while Cath is not what could truthfully be called a perfect gentleman, she's a real manly young lady, just the same.

It was a happy new year's beginning for a few electricians and boilermakers at the New York navy yard. The master electrician now gets $9.04 a day instead of $8, and the master boiler maker $7.04 instead of $6.24. Now, boys, remember your home obligations and don't hold out on those few odd cents.

Yes, Ignatius, dirt in a governor does operate against its efficiency. As a case in point, Cole Blease, a very soiled governor of good old South C'rlina, attempted to start something the other day by consigning the Constitution to Hades, along with everybody else who had the temerity to disagree with him. They used to call him "Coley" in the old days; what they call him now isn't fit to print.

We are pleased to receive a circular from Greenwood's woodyard, Woodsville, N. H., announcing "mixed wood at $3 a load. This wood can be seen at Mr. Long's brick yard. Carrying upstairs, 35c. extra." Any Woodsville man who gets a $3 load may be lucky, but if he's inclined to throw things he should keep away from Mr. Lang's brickyard. Charging 35c. for carrying a load upstairs seems a trifle excessive. Many a load has been thrown down stairs free of charge, and the distance up is no greater.

Wish we could put J. Sharshall Grarsty in our Hall of Fame, but he's not an operating engineer; just a Ph.D., a scholar, a gentleman and an editor of "The Tradesman," of Chattanooga, Tenn. The loss is ours, doctor, but we are respectfully curious to know if the "J" might stand for Jiphthahel or Jonadab? Of course, it might, but does it?

Central Station vs. Isolated Plant

By Warren B. Lewis

Arguments in the case of the central station vs. the isolated plant, seem to be never-ending; now a new proposition is a summer central station and a winter isolated plant.

Unfortunately little has been brought to light relative to this phase of generating electrical energy, but a few facts are herewith presented concerning a typical office building, which may serve to center the argument on something definite. It would be interesting to know wherein other office buildings differ in their general requirements.

The building is ten stories high and of modern fireproof construction. It covers a ground area of approximately 20,000 sq.ft. For several years it has been purchasing central-station current, but operating its own hydraulic elevator steam pumps, and heating with direct-steam radiation. The owners proposed installing a plant for lighting purposes.

A careful investigation showed that the maximum demand during daylight office hours was about 20 kw., chiefly in the form of elevator lighting and a small amount of corridor lighting. The maximum energy at 5 o'clock in the afternoon of a winter day was 150 kw. Current is metered to all the tenants. The total energy purchased from the central station had averaged for three years, 50,000 kw.-hr. per year.

Here were definite conditions to be met, with a record of the cost of operation under the existing conditions. Bids were taken for a plant consisting of one 25-kw. unit and two 100-kw. units, on the theory that the small unit would take care of the day lighting, and should one of the large units be out of service, the maximum peak load could be carried on the other large one and the small unit. It was found that the cost of the plant, when completely installed, would be approximately $20,000. A number of small items could only be estimated; but the figure given represented the sum total of all the material and labor which would enter into the installation of the plant.

Allowing 5 per cent. for interest, 5 per cent. for depreciation, and 2 per cent. for repairs, there would be a fixed charge of $2,400 per year, which, divided by 50,000, gave a cost of 4.8 cents per kw.-hr. for fixed charges alone. At this point it seemed rather unnecessary to pursue the investigation any further, as current was being purchased for but slightly more than this amount.

It may be claimed that the maximum capacity of the plant was out of proportion to the total energy used; but it should be remembered that the tenant who buys metered current is apt to be careful in the use of light, and the load factor of such a plant would be exceedingly small. In fact, the amount of energy used during daylight hours, while not exceeding a maximum demand of 20 kw. was in the aggregate, fully half of the total energy purchased. The total time over which the peak load exists is hardly 300 hr. a year.

Statements that exhaust steam is a great factor in lessening the cost of power, can be easily over-emphasized; for example, it is seldom that, in this plant, enough exhaust steam would be available when heat was wanted. The day load would not furnish enough exhaust steam to heat the building, and during the hours of the peak load the exhaust steam would not be required as the building would be already warm.

In one instance an isolated plant was operated with a day load nearly half of the peak load and their isolated plant appeared to be a good investment. It developed that tenants paid for lights on the basis of a flat rate, with the result that a great many unnecessary lamps were burning all day. That building is now using central-station current, metering the current to all tenants, and the day load has decreased to a mere fraction of what it was before.

NEW PUBLICATIONS

THE STEAM ENGINE AND TURBINE. By Prof. R. H. C. Heck. Published by D. Van Nostrand & Co., New York. Cloth; 631 pages, 5¾x9¼ in.; 402 illustrations; charts; tables. Price, $5.

This is a textbook for engineering colleges and assumes that the student has an elementary knowledge of physics and mathematics. The object of the book is to give the student a knowledge of the theory and general construction of steam motors, no attempt being made to teach either design or operation.

In the first part of the book, the theory of the heat engine, properties of steam and the ideal engine cycles are discussed. Indicator diagrams are then taken up and methods of interpreting them shown. Engine efficiencies are defined and illustrated by numerous examples. Diagrams are given of the various forces in the engine and the construction of its principal parts. Standard types of valve-gears and governors are described, their construction illustrated by diagrams and their functions explained.

The steam turbine is taken up, jet action discussed and tables of turbine performance given. The designs of several types of turbines are explained, numerous illustrations given of the various types and the construction of their working parts.

The book is concluded by a chapter on steam jet blowers, injectors, condensers and other forms of auxiliary apparatus.

Steam tables based on the same data as those of Marks and Davis are given in the appendix.

Three tables of efficiencies, engine, turbine and condenser, are included in the text, which are well worked up and quite valuable. The arrangement of these tables is unusual to say the least, and the peculiar nomenclature necessitates considerable labor in their use. It is unfortunate that books intended for use in schools should not use as far as possible standard symbols.

AN INTRODUCTORY TO THE STUDY OF FUEL. By F. J. Brislee, D. Sc. D. Van Nostrand Co., New York City. Cloth; 269 pages; 6x9 in.; 61 illustrations. Price, $3.

This book is the first of a series of volumes treating the subject of industrial chemistry under the general title "Outlines of Industrial Chemistry." The purpose of each volume is "to provide students and persons employed on the technical side of any particular industry with a handbook explaining the chemical aspect of the operations carried on in that industry." If the others of the series are like the present volume they will be found interesting to those engaged in the business end of the industries to which they relate because only an elementary knowledge of chemistry is necessary to understand most of the subjects treated.

The first two chapters treat of the chemistry of combustion and include a consideration of reacting substances, reaction velocity and the use of catalysers to accelerate the velocity of reactions. The next chapter deals with the analysis of fuel and flue gases and proves very instructive. Directions are given for the use of Hempel, Orsat and Stead apparatus. The precautions to be observed in taking and analyzing a flue-gas sample are enumerated.

Calorimetry is the subject of Chapter IV and includes instructions for using several well known calorimeters. Chapter V describes the many kinds of pyrometers for furnace control, and special attention is given to the Féry radiation pyrometer.

After a rather technical discussion of combustion temperature calculations in Chapter VI, the classification and composition of various fuels are treated. A simple laboratory test is described for identifying the class to which a coal belongs, i.e., as to whether it is a caking or noncaking coal.

Another chapter treats the subject of coke, coke making and the recovery of the byproducts. A few types of coke ovens are described and the commercial value of briquetted coal is discussed.

The composition of natural gas, and the composition and commercial combustion of producer, water and blast-furnace gas are also covered and a chapter on the chemistry of rapid combustion or explosion contains an instructive explanation of the combustion of fuels and heat losses in explosion motors.

The last four chapters treat of "Air Supply and Measurement of Draft," "Furnace Efficiency and Fuel Economy," "Heat Balances, Furnace and Boiler Tests" and "Liquid Fuels," and are particularly useful to the power-plant engineer.

The author recommends the purchase of coal upon the basis of its heating value, and then proceeds to point out the fallacy of the objections raised against this practice. He believes that coal samples are not selected with sufficient care to be truly representative of the total quantity and that this is the chief reason for the prejudice so prevalent against this system of purchase.

The University of Illinois has issued a revision of bulletin No. 9, dealing with "An Extension of the Dewey Decimal System of Classification Applied to the Engineering Industry," by Professors L. P. Breckenridge and D. A. Goodenough. This may be obtained by addressing the Engineering Experiment Station, Urbana, Ill. Price, 50 cents.

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Nine Men Killed in Hamlet, N. C., Boiler Explosion

As the result of the explosion of a stationary boiler in the Seaboard Air Line Ry. shops, at Hamlet, N. C., on Dec. 28, according to press reports, nine men were killed including the roundhouse foreman, the assistant foreman and an electrician.

One part of the boiler was hurled through an 18-in. wall and thrown 500 ft. away. The body of one of the negroes employees was found over 200 ft. from the building. No reasonable cause is given, but we hope to publish the details in an early issue.

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Special Engineering Lecture Course at Stevens Institute

A special lecture course on engineering topics has been introduced as a regular part of the curriculm for the students of the senior class, Stevens Institute of Technology. These lectures are delivered by well known men actively engaged in the work of which they speak. Some of the lectures and subjects for the first half of the senior year are:

John Calder, of the Cadillac Motor Co., six lectures on shop management, including organization, system, foremen and workmen, industrial hygiene, the modern plant, and the engineer's social relations.

Dr. D. S. Jacobus, advisory engineer, Babcock & Wilcox Co., formerly professor of experimental engineering at Stevens Institute of Technology, two lectures on boilers and power plants.

Henry C. Meyer, Jr., consulting mechanical engineer, New York City, two lectures on heating and ventilating.

Walter Kidde, engineer constructor, New York City, a lecture on power plants for manufacturing and other establishments.

Another course of lectures on engineering topics is now being arranged for the second half of the senior year.

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The American Society of Mechanical Engineers has received an inquiry from the Milwaukee Engineering Society with respect to affiliation. Vice-president George M. Brill was appointed to extend the society's greeting to the Milwaukee organization.

W. R. Griffin, general manager of the Tri-State Railway & Electric Co., announces that his concern will build a $2,000,000 power house on a site near Midland, Penn. The company has obtained control of coal mines near at hand for fuel. The J. G. White Engineering Co., New York, will have charge of the work.

The Goulds Mfg. Co., Seneca Falls, N. Y., announces that the Mine & Smelter Supply Co., Denver, Colo., has been appointed as agent for the Goulds line of triplex power pumps. Its territory will include the entire state of Colorado and adjacent counties in Wyoming, New Mexico, South Dakota and Montana.

Annual Meeting of the Efficiency Society

The annual meeting of the Efficiency Society will be convened on Monday, Jan. 27, at 9:30 a.m., in the Engineering Societies Building, 39 West Thirty-ninth St., New York City. The following tentative program has been outlined:

Monday, Jan. 27

9:30 a.m. President's address.
Business meeting.
Election of directors.
10:30 a.m. Symposium on organization.
Discussion on the necessity of charts of organization.
1:00 p.m. Adjournment for luncheon.
2:00 p.m. Symposium on management.
Discussion on democracy in industry and "securing the consent of the governed."
5:00 p.m. Adjournment.
7:00 p.m. Dinner at the Aldine Club, 200 Fifth Ave.
8:30 p.m. Symposium on efficiency in the Government organization, national, state and municipal.
Discussion on a readjustment of the governmental departments.
10:30 p.m. Adjournment.

Tuesday, Jan. 28

10:00 a.m. Symposium on industrial relations.
Discussion on the relations between employer, employee and the community.
1:00 p.m. Adjournment for luncheon.
2:00 p.m. Symposium on industrial hygiene and safeguards against occupational disease and accident.
3:30 p.m. Symposium on safety.
(1) In marine transportation.
(2) In land transportation.
(3) In crowded buildings.
(4) From city conflagrations.
(5) From forest fires.
(6) In mines
(7) In dam protected districts.
(8) From freshet floods.

This session will be illustrated by moving pictures and lantern slides demonstrating the efficiency obtained by conserving the human element in industry.
5:00 p.m. Closing business session.
5:30 p.m. Final adjournment.

SOCIETY NOTES

The Detroit Engineering Society will, at its regular meeting, Jan. 17, at the Employers Association Rooms, Stevens Bldg., Detroit, discuss the subject, "The Pennsylvania Terminal, New York City," by H. O. Pond, of Westinghouse, Church, Kerr & Co., New York City.

The annual banquet of the Ithaca section of the American Institute of Electrical Engineers will be held in Sibley Dome, Cornell University, on the evening of Jan 11. The principal speaker of the evening will probably be R. D. Mershon, president of the American Institute of Electrical Engineers, of New York City. The program will include several several musical numbers and song hits on members of the faculty.

PERSONALS

William Stanley, Great Barrington, Mass., has been awarded the fourth Edison medal "for meritorious achievement in invention and development of alternating-current systems and apparatus."

OBITUARY

GEORGE BURNHAM

George Burnham, Sr., Philadelphia, Penn., formerly a partner in Burnham, Williams & Co., Baldwin Locomotive Works, and an associate of Matthias W. Baldwin, the founder of the works, died Dec. 10, aged 95 years. Mr. Burnham became identified with the Baldwin Works in the early days of locomotive building, and in 1867, following the death of Mr. Baldwin, became a member of the firm, then styled M. Baird & Co. On Mr. Baird's retirement, in 1873, Mr. Burnham became senior member of the firm then known as Burnham, Parry, Williams & Co., and later as Burnham, Williams & Co., which continued until the incorporation of the business in 1909 as the Baldwin Locomotive Works. Mr. Burnham's connection with the industry covered 73 years. He was born at Springfield, Mass., and when about 15 years of age went to Philadelphia. He leaves two sons and a daughter.